RADFORD ARMY AMMUNITION PLANT, VIRGINIA

SWMUs 48 and 49
RCRA Facility Investigation Report

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
ADAF	Age-Dependent Adjustment Factor
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area Use Factor
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CCA	Copper Chromated Arsenate
CCME	Canadian Council of Ministers of the Environment
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeters
CNS	Central Nervous System
COI	Contaminant of Interest
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
Cr(III)	Trivalent Chromium
Cr(VI)	Hexavalent Chromium
CSEM	Conceptual Site Exposure Model
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CT	Carbon Tetrachloride
DA	dose absorbed per unit area per event
DCA	Dichloroethane
DCE	Dichloroethene
DNB	Dinitrobenzene
DNT	Dinitrotoluene
DO	Dissolved Oxygen
DQO	Data Quality Objective
EcoSSL	Ecological Soil Screening Level
EEQ	Environmental Effects Quotient
EPC	Exposure Point Concentration
EPD	Effective Prediction Domain
ERAGS	Ecological Risk Assessment Guidance for Superfund
FA	fraction absorbed dose
FOD	Frequency of Detection
ft msl	feet above mean sea level
ft	foot/feet
g/dL	grams per deciliter
GI	Gastrointestinal
GPS	Global Positioning System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HSA	Horseshoe Area
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
i-SL	Industrial Screening Level
LOAEL	Lowest-Observed-Adverse-Effect Level
MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MDL	Method Detection Limit
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mm Hg	millimeters mercury
MNA	Monitored Natural Attenuation
MOA	Mode of Action
mV	millivolts

MW	Molecular Weight(s)
MWP	Master Work Plan
NIBC	Not Important Bioaccumulative Constituents
NOAEL	No-Observed-Adverse-Effect Level
ORNL	Oak Ridge National Laboratory
ORP	Oxidation-Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PCP	Pentachlorophenol
PEF	Particulate Emission Factor
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	Preliminary Remedial Goal
QA	Quality Assurance
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Daily Allowance
RFA	RCRA Facility Assessment
RFAAP	Radford Army Ammunition Plant
RfD	Risk Reference Dose
RFI	RCRA Facility Investigation
RG	Remedial Goal
RSL	Regional Screening Level
r-SL	Residential Screening Level
RTE	Rare, Threatened, or Endangered
Shaw	Shaw Environmental, Inc.
SL	Screening Level
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific/Management Decision Point
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leachate Procedure
TE	Toxicity Equivalents
TEF	Toxicity Equivalent Factor
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TOX	Total Organic Halides
TPH	Total Petroleum Hydrocarbons
TRV	Toxicity Reference Value
tw-SL	Tap Water Screening Level
UCL	Upper Confidence Limit
UF	Uncertainty Factor
USAEC	U.S. Army Environmental Command
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USEPA	U.S. Environmental Protection Agency
UTL	Upper Tolerance Limit
VDEQ	Virginia Department of Environmental Quality
VI	Verification Investigation
VOC	Volatile Organic Compound
VRP	Voluntary Remediation Program
WHO	World Health Organization
XRF	X-ray Fluorescence

EXECUTIVE SUMMARY

Shaw Environmental, Inc. (Shaw) conducted a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Solid Waste Management Unit (SWMU) 48 (RAAP-18) - the Oily Water Burial Area, and SWMU 49 (RAAP-13) - Red Water Ash Burial #2 during 2007. These investigations are required by the 2000 RCRA Corrective Action permit [U.S. Environmental Protection Agency (USEPA), 2000a] for Radford Army Ammunition Plant and were performed in accordance with *Master Work Plan (MWP) Addendum 019* (Shaw, 2007). MWP Addendum 019 was prepared to facilitate the investigation effort to comply with the requirements set forth in the 2000 RCRA Corrective Action permit and was approved by USEPA Region III and the Virginia Department of Environmental Quality (VDEQ).

Previous investigations combined sites SWMUs 48, 49, 50, and 59 into one study site. However, SWMUs 50 and 59 were addressed in a separate RFI (Shaw, 2009) that recommended No Further Action and was approved by USEPA and VDEQ in October 2009. In addition, SWMUs 48 and 49 are associated because in previous reports their descriptive titles have been mixed-up and because of their close proximity to each other. The groundwater samples taken from wells at SWMUs 48, 49, 50, and 59 were all assessed in this report since the sites are so close in proximity and the contamination appears to be originating from SWMU 49.

In addition to the MWP Addendum 019 field investigation, six previous field investigations were conducted at SWMUs 48 and 49 between 1987 and 2006. These investigations provide a good, long-term dataset that, in conjunction with the current data, can be used to assess concentrations over time.

During the development of MWP Addendum 019, a review of the data indicated that additional wells were needed to delineate the extent of constituents in groundwater. Groundwater samples from previous investigations at the four sites had not been analyzed for perchlorate or herbicides, representing another data gap. Additional soil sampling at SWMU 49 was performed to provide additional data for a risk assessment at that site. Soil at SWMU 48 was considered sufficiently characterized through the sampling performed in the previous investigations.

Activities from the 2007 RFI included the installation of four new monitoring wells and the collection and chemical analysis of groundwater samples from the new and existing wells in the area. Four surface soil samples and three subsurface soil samples were also collected from SWMU 49.

After regulatory review of an earlier version of the draft RFI, a supplemental data investigation was conducted in 2010 and consisted of the advancement of a series of test pits perpendicular to the trenches at SWMU 48 and subsurface soil sampling. Although the elevated detection of 2,4,6-trinitrotoluene (TNT) from 1998 could not be duplicated during the investigation, bags of an unknown clayey substance found to contain high metals concentrations were uncovered. Based on the discovery of the bags and the high concentrations of metals detected in the clayey substance, an Interim Measures Removal Action was performed in 2011, and impacted soil, the ash layer, and debris, including the clayey substance, were removed from the southern trench of SWMU 48 and disposed of offsite.

Review of the 2007 RFI groundwater data indicated that further investigation was required to delineate the extent of chlorinated solvents in groundwater in the SWMU 48/49 area. In an effort to complete the RFI at these sites, a Supplemental RFI was performed in 2013 that included the installation of four additional groundwater monitoring wells to the south and east of SWMUs 48 and 49. These four new wells and 10 existing wells were sampled in May 2013 to further define the extent of chlorinated solvents in groundwater.

Contamination Assessment

Soil – SWMU 48. The primary concern in soil at SWMU 48 was 2,4,6-TNT and 2,4-dinitrotoluene (DNT), located within a thin ash layer near the base of the southern trench during the 1998 RFI. Concentrations of explosives above screening levels (SLs) were limited to three samples collected in the southern trench. Subsurface samples 48SB07A [8-9 feet (ft) below ground surface (bgs)] and 48TP1 (6-6.5 ft bgs) were both collected from soil containing ash. Sample 48SB7B (10-11 ft bgs) was collected directly below sample 48SB7A and indicated a marked decrease in the concentration of 2,4,6-TNT.

Shaw conducted a supplemental data investigation and additional sampling in 2010 to visibly locate the ash layer within the SWMU 48 trenches via test pitting and characterize the concentrations of explosives in the soil above, within, and below the ash layer. Visual observations during the test pitting indicated that the thickness of the ash layer generally ranged from approximately 0.3 to 2.0 ft and also demonstrated that the ash layer was present through much of the length of the southern trench. In addition, lenses of plastics, roofing materials, asphalt debris, and an unknown green clayey substance were encountered in some of the test pits. Sample results from the investigation indicated that the elevated TNT levels detected in 1998 were isolated and anomalous results that could not be replicated. Test pit sample results also indicated that metal concentrations, specifically, lead, antimony, arsenic, cadmium, copper, and mercury, were present at concentrations posing a threat to human health and the environment at SWMU 48.

Based upon the 2010 investigation sample results, an interim measures remedial action was performed to address the elevated concentrations of metals in SWMU 48 soil. In compliance with the *SWMU 48 Interim Measures Work Plan* (Shaw, 2011), the source material for contamination at SWMU 48, the debris and ash layer was removed. As presented in the *SWMU 48 Interim Measures Completion Report* (Shaw, 2012), sample results from x-ray fluorescence screening and laboratory confirmation samples indicated that all contaminated soils have been removed to or below the industrial remedial goals (RGs) selected for arsenic, antimony, cadmium, copper, lead, and mercury. The cleanup efforts at SWMU 48 achieved residential soil RGs, and the site is now suitable for unrestricted re-use. Therefore, soil at SWMU 48 is not considered a concern.

Soil – SWMU 49. The soil at SWMU 49 was investigated during five investigation efforts spanning from 1991 through 2007. Sample results from the investigations indicate that explosives, herbicides, metals, and dioxins/furans were not detected at concentrations above residential SLs (r-SLs) or industrial SLs (i-SLs) in any of the soil samples collected at the site and are not considered a concern in soil at SWMU 49. The only analytes detected above SLs included two semivolatile organic compounds (SVOCs) [bis(2-ethylhexyl)phthalate and naphthalene], two polychlorinated biphenyls (PCBs; PCB-1232 and PCB-1254), and total petroleum hydrocarbons (TPH). Bis(2-ethylhexyl)phthalate was only detected in one soil sample at a concentration marginally above its r-SL (but below its i-SL).

Bis(2-ethylhexyl)phthalate is a common laboratory contaminant that is not site related, and its presence in a single soil sample above its r-SL is not a concern in soil at the site. Naphthalene was detected above its r-SL (but below its i-SL) in one subsurface soil sample and above its i-SL in one other subsurface soil sample (48SB5A19). Naphthalene was not detected in subsurface soil sample 48SB5B37, collected below 48SB5A19, where naphthalene was detected above its i-SL; this indicates that naphthalene is not vertically migrating, and its presence at an elevated concentration in a couple site soil samples is isolated and not considered a concern in site soil.

The most likely source for PCBs in soil was the oily water that was reportedly disposed of in the SWMU 48/49 area. PCBs are highly immobile in the environment and their presence at that depth (and not shallower) is likely due to the fact that the PCBs were entrained with the oily water when it was dumped. The low mobility of PCBs appears to have caused the PCBs to bind to soil particles, thus preventing downward migration. Groundwater sample results from the 2007 RFI sampling effort indicate that PCBs were not detected in any of the 11 groundwater samples collected at the combined study area. Therefore, PCBs are not considered a concern in soil or groundwater at SWMUs 48 or 49.

Similar to the potential source for PCBs detected in soil at the site, it is likely that the source for the TPH in soil was the oily water that was reportedly disposed of in the SWMU 48/49 area. Other than the single occurrence of TPH at an elevated concentration in one site surface soil sample, elevated TPH concentrations were isolated to two subsurface soil samples collected from 17 to 19 ft bgs. Subsurface soil results from samples collected below 17 to 19 ft bgs in the same boring indicate that TPH was not detected, demonstrating that elevated concentrations of TPH are isolated and not migrating downward. In addition, the elevated concentrations of TPH at 17 to 19 ft bgs are present at depths below what human and ecological receptors are exposed.

Groundwater. The contamination assessment and the human health risk assessment (HHRA) identified several volatile organic compounds (VOCs) and metals as elevated and contributing to potential future risks. Two of the VOCs associated with potential future industrial and residential risk in the HHRA [carbon tetrachloride (CT) and trichloroethene (TCE)] were present above USEPA's Maximum Contaminant Levels (USEPA, 2006) during the multiple groundwater sampling events at the combined study area. The highest VOC concentrations of CT and TCE were found in wells 48MW2 and 48MW3, where the center of the plumes is located. The CT plume is oval in shape, approximately 250 ft in length (north to south) and 680 ft wide (east to west), and is delineated in all directions. The center of the plume (highest detected concentrations) is located approximately 205 ft southeast of SWMU 49. The upgradient edge of the plume is located approximately 250 ft to the northwest from the center of the plume. The TCE plume is triangular in shape, is approximately 560 ft in length (north to south) and 580 ft wide (east to west), and is delineated in all directions. The center of the plume (highest detected concentrations) is located approximately 210 ft southeast of SWMU 49. The upgradient edge of the plume is located approximately 300 ft to the northwest from the center of the plume and extends into SWMU 48.

A comparison in concentrations from the mid-1990s to 2013 indicates that the majority of the VOCs are no longer present in these sampled areas and have broken down through natural processes. Analysis of the groundwater data during this roughly 20-year period shows that concentrations of CT and TCE plume have: 1) decreased overall, 2) decreased to 1 microgram per liter surrounding the center of the plume, and 3) decreased at least by one half in the center of the plume. The presence of daughter products [i.e., chloroform and cis-1,2-dichloroethene (DCE)] in groundwater at the combined study area indicates that limited biological degradation of the chlorinated solvents is occurring.

Human Health Risk Assessment

An HHRA (*Section 6.0*) was conducted at SWMUs 48 and 49 to evaluate the potential human health risks associated with previous activities at the site. Risks associated with surface soil, total soil, and groundwater were evaluated for several different current and hypothetical future exposure scenarios. Risks and hazards from these scenarios are summarized below.

SWMU 48

At SWMU 48, the total cancer risk for current and future maintenance worker, future industrial worker, and future excavation worker exposures to surface soil were within or below the target risk range of 1E-06 to 1E-04. The total hazard indices (HIs) were less than 1. For current and future maintenance worker and future excavation worker, the total cancer risk associated with groundwater was below the target risk range and the total HI was less than 1. For the future industrial worker, the total cancer risk associated with groundwater (1E-04) was equal to the upper limit of the target risk range of 1E-06 to 1E-04. The total HI (2E+01) was above 1, primarily due to cobalt, iron, manganese, and thallium. The maximum detected concentration (MDC) and the arithmetic mean of lead in groundwater is greater than the action level for lead in drinking water.

For the future lifetime resident (and off-site resident), the total cancer risks associated with total soil (1E-05) were within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. For future adult residents, the total HI for total soil was less than 1. The total cancer risk associated with groundwater (2E-03) was above the target risk range of 1E-06 to 1E-04. For future adult resident exposures, the total HI (9E+01) was above 1. The MDC for lead in groundwater was above the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For the child resident, the total cancer risks associated with total soil (9E-06) was within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. For future child residents, the total HI (4E+00) was above 1; however, there were no individual chemicals of potential concern (COPCs) with HIs above 1. The total cancer risk associated with groundwater (onsite and offsite) (6E-04) was above the target risk range of 1E-06 to 1E-04. For future child resident exposures, the total HI (1E+02) was above 1. It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. For the residential scenario, site concentrations in groundwater were above the health protective criterion for lead.

SWMU 49

At SWMU 49, the total cancer risk for current and future maintenance worker, future industrial worker, and future excavation worker exposures to surface soil and/or total soil was within or below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. The total cancer risk for current and future maintenance worker and future excavation worker exposures associated with groundwater (onsite and offsite) was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

The total cancer risk for future industrial worker exposures associated with groundwater (onsite and offsite) (1E-04) was equal to the upper limit of the target risk range of 1E-06 to 1E-04. The total HI (2E+01) was above 1. The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For the future lifetime resident, the total cancer risks associated with total soil (5E-05) were within the target risk range. For future adult residents, the total HI for total soil was less than 1. The total cancer risk associated with groundwater (onsite and offsite) (2E-03) was above the target risk range of 1E-06 to 1E-04. For future adult resident exposures, the total HI (9E+01) was above 1. The MDC and the arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For the future child resident, the total cancer risk associated with total soil (4E-05) was within the target risk range. The total HI (3E+00) was above 1; however, there were no individual COPCs with HIs above 1. The total cancer risk associated with groundwater (onsite and offsite) (6E-04) was above the target risk range of 1E-06 to 1E-04. The total HI (1E+02) was above 1. The margin-of-exposure evaluation for iron indicated that the iron intake was above the allowable range.

Screening Level Ecological Risk Assessment

The data, results, and conclusions of the screening level ecological risk assessment (SLERA) evaluated risks to ecological populations inhabiting SWMU 48. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-9**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-10** and discussed in *Section 7.2.4.1*.

The food chain Tier 2 no-observed-adverse-effect level assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (arsenic; chromium; lead; mercury; zinc; Aroclor 1254; 4,4-DDT; 4,4-DDD; and TCDD) in surface soil. Based on Tier 2 lowest-observed-adverse-effect level (LOAEL)-based approach, only chromium for the robin and TCDD for the shrew had estimated environmental effects quotients (EEQs) greater than 1 when rounded to one significant figure. In addition, when alternative exposure and/or toxicity factors were used in the SLERA EEQ calculation for these two receptors, estimated EEQs would be expected to drop to 1 or less. The direct contact assessment results suggest a potential reduction in wildlife food supply due to barium and mercury in surface soil; however, due to the small size of the site (1 acre), this potential reduction in food is not considered biologically significant. Analysis of the site and background data indicates that all of the Tier 2 inorganic chemical of potential ecological concern (COPEC) drivers (chromium, mercury, and zinc) and the direct contact constituent mercury are statistically related to naturally-occurring surface soil concentrations (*Section 7.2.5*).

Based on uncertainties of toxicity, the finding that chromium, mercury, and zinc concentrations are background related, the fact that no wildlife rare, threatened, or endangered (RTE) species have been confirmed at the SWMU study area, alternative exposure and/or toxicity factors that could be used, and the relatively small size of the SWMU (1.0 acre), additional remedial measures solely to address ecological concerns are not warranted for soil. The scientific/management decision point (SMDP) reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 49. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-16**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-17** and discussed in *Section 7.3.4.1*.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews and voles for modeled contact with the hazard drivers (primarily selenium and TCDD) in surface soil. Use of alternative SLERA parameters would reduce the estimated Tier 2 LOAEL-based EEQs to essentially 1, except for selenium exposure for the meadow vole. However, the small size of the site may not be able to support enough small mammals for a sustainable breeding population. The direct contact assessment results suggest a potential reduction in terrestrial invertebrate wildlife food supply due to lead and mercury in surface soil; however, given the small size of the site, it is unlikely that the potential loss of prey would be biologically significant. Analysis of the site and background data indicates that of the three inorganic COPEC drivers, lead is background related [i.e., statistically related to naturally-occurring surface soil concentrations (*Section 7.3.5*)].

Based on uncertainties of toxicity, the potential that lead concentrations are background related, the fact that no wildlife RTE species have been confirmed at the SWMU study area, and the relatively small size of the site (0.1 acre), remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

For both SWMUs 48 and 49, migration of COPECs in groundwater to surface water and sediment of the New River was determined unlikely due to the distance of this receptor area from the site and therefore was not deemed to be an ecological concern.

The SWMU 48 and 49 assessment results may serve as the foci of discussions with risk managers and regulatory agencies. It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

Recommendations

Soil

SWMU 48. As presented in the *SWMU 48 Interim Measures Completion Report* (Shaw, 2012), soil constituents have been remediated to below industrial standards. Additionally, the cleanup efforts at SWMU 48 achieved residential soil RGs, and the site is now suitable for unrestricted re-use. The Army requests a Response Complete determination for SWMU 48, as the results of the Interim Measures and the contamination assessment indicate that No Further Action is required for the site.

SWMU 49. The contamination assessment of SWMU 49 indicates that explosives, herbicides, metals, and dioxins/furans were not detected at concentrations above r-SLs or i-SLs in any of the soil samples collected at the site and are not considered a concern in soil at SWMU 49. The only analytes detected above SLs included two SVOCs [bis(2-ethylhexyl)phthalate and naphthalene], two PCBs (PCB-1232 and PCB-1254), and TPH. Analysis of the soil data indicates that these analytes are not considered a concern in soil at SWMU 49.

The HHRA indicated that the total cancer risk for current and future maintenance worker, future industrial worker, and future excavation worker exposures to surface soil and/or total soil was within or below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. For the future child resident, the total cancer risk associated with total soil (4E-05) was within the target risk range. The total HI (3E+00) was above 1; however, there were no individual COPCs with HIs above 1.

The SLERA indicated that the food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews and voles for modeled contact with the hazard drivers. The direct contact assessment results suggest a potential reduction in terrestrial invertebrate wildlife food supply due to lead and mercury in surface soil. Based on uncertainties of toxicity, the potential that lead concentrations are background related, the fact that no wildlife RTE species have been confirmed at the study area, and the relatively small size of the site (0.1 acre), remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

Based on the findings from the contamination assessment, HHRA, and SLERA, the site is suitable for unrestricted use and No Further Action is recommended for soil at SWMU 49.

Groundwater

Groundwater at the combined study area has been investigated from the mid-1990s through 2013 and has been fully characterized and delineated. Based on the contamination assessment and the HHRA, CT and TCE are the primary constituents of concern that are contributing potential future industrial and residential risk at the combined study area. Results from the monitored natural attenuation (MNA) analysis conducted for the combined study area groundwater (*Section 4.6*) indicated that MNA processes including biodegradation, sorption, dilution, dispersion, and chemical stabilization are occurring in groundwater at the combined study area. The following conclusions were derived from the MNA analysis:

- Decreases in TCE and CT concentrations have occurred from 1995 to 2013 and indicate that MNA processes are aiding in the reduction of contaminated concentrations.
- The presence of daughter products cis-1,2-DCE and chloroform suggests that limited biological degradation has occurred, which also may be aiding in removing mass in the groundwater.
- The geochemical parameters, including dissolved oxygen, oxidation-reduction potential, anions, and total organic carbon indicate that groundwater conditions are generally aerobic and not favorable for the complete biological reducing of TCE and CT.
- Additional sampling is required to obtain a more complete data set for the evaluation of site characteristics and further analyze contaminant concentrations in the combined study area.

Based on the findings from the contamination assessment, MNA analysis, and HHRA, long-term monitoring of the combined study area groundwater is recommended to further evaluate contaminant concentrations and MNA of contaminants in groundwater at the combined study area.

1.0 INTRODUCTION

Shaw Environmental, Inc. (Shaw) was tasked by the U.S. Army Corps of Engineers, Baltimore District, to perform a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) and Corrective Measures Study at Solid Waste Management Unit (SWMU) 48 (RAAP-18) - the Oily Water Burial Area and SWMU 49 (RAAP-13) - the Red Water Ash Burial No. 2. The SWMUs are located adjacent to one another in the southeastern portion of the Horseshoe Area (HSA) of Radford Army Ammunition Plant (RFAAP), east of the main bridge over the New River (**Figure 1-1**). The work was performed in accordance with RFAAP's *Master Work Plan (MWP)* (URS, 2003) and *MWP Addendum 019* (Shaw, 2007) under Contract No. W912QR-04-D-0027.

Previous investigations have been conducted as a collective effort at or adjacent to SWMUs 48 and 49 and are discussed in the following section of this report. A data review, including the development of a conceptual site model (CSM) and a data gap analysis, was performed in *MWP Addendum 019* (Shaw, 2007). Review of the data indicated that additional samples needed to be collected to characterize the current state of potentially impacted media, representing a data gap. Once the data needs were identified, sampling strategies were developed to complete the characterization of SWMUs 48 and 49.

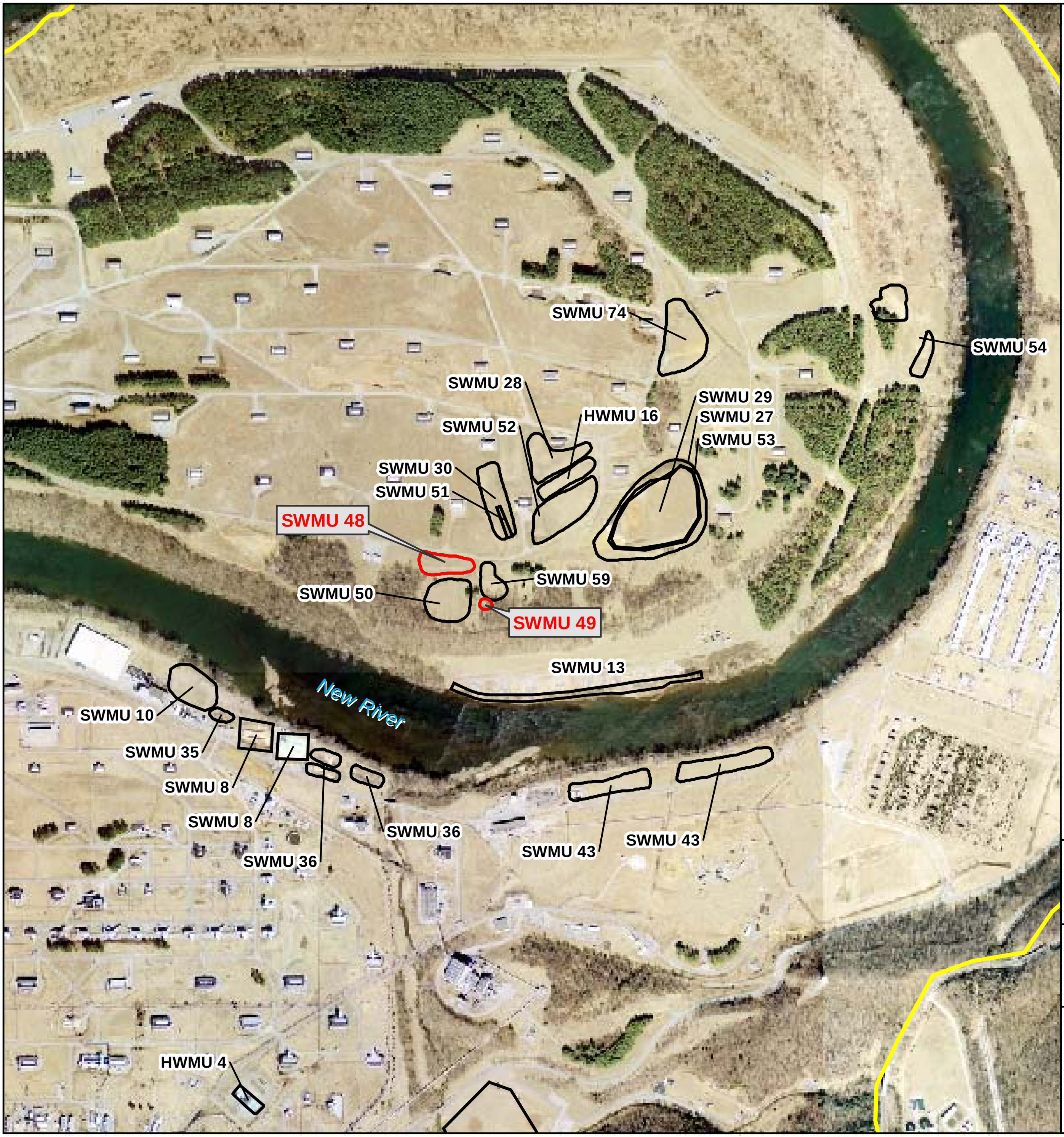
The objectives of the field investigation at SWMUs 48 and 49 were designed to:

- Collect sufficient samples in order to complete risk assessments.
- Further delineate identified "hotspots" in soil.
- Provide additional coverage in lateral and vertical dimensions at the sites.
- Further characterize groundwater so that a groundwater component could be added to the human health risk assessment (HHRA).

Field activities were conducted in accordance with the *MWP, Master Quality Assurance Plan, Master Health and Safety Plan* (URS, 2003), *MWP Addendum 012* (IT, 2002a), and *MWP Addendum 019* (Shaw, 2007), as approved by the U.S. Environmental Protection Agency (USEPA) Region III and the Virginia Department of Environmental Quality (VDEQ). Modifications to MWP Addendum 019 proposed sampling activities are presented in *Section 3.1.5*.

The data collected in 2007, in conjunction with existing data, and recent data collected in 2010 and 2011 was sufficient to complete a Nature and Extent of Contamination Assessment (*Section 4.0*), Fate and Transport Evaluation (*Section 5.0*), HHRA (*Section 6.0*), and Screening Level Ecological Risk Assessment (SLERA) (*Section 7.0*).

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig1-1_SWMU48_49_SiteLocMap.mxd (4/8/2013)



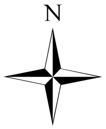
LEGEND

🟥 SWMU 48 and SWMU 49 Boundaries

⬛ Other SWMU Boundary

🟨 Installation Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning & GIS Services.



Scale:
0 500 1,000 2,000
Feet

U.S. Army Corps of Engineers

Shaw Environmental, Inc.
(A CB&I Company)
4696 Millennium Drive, Suite 320
Belcamp, Maryland 21017

FIGURE 1-1
SWMU 48 and SWMU 49
Site Location Map
Radford Army Ammunition Plant,
Radford, VA

2.0 SITE BACKGROUND

2.1 Site Description

The combined study area (SWMUs 48 and 49) is located in the southeastern portion of the RFAAP HSA, east of the main bridge over the New River. As illustrated on **Figure 2-1**, the two SWMUs are adjacent, with SWMU 48 located approximately 200 feet (ft) northwest of SWMU 49.

The SWMU 48 study area is approximately 380 ft long by 120 ft wide; whereas, the SWMU 49 study area is 75 ft long by 83 ft wide. The combined study area is situated on a bluff approximately 120 ft above and overlooking SWMU 13 and the New River. The land surface in the combined study area gently slopes from approximately 1,830 feet above mean sea level (ft msl) on the north side of SWMU 48, to approximately 1,816 ft msl on the southeast side of SWMU 49. Based on topography, surface water runoff is expected to flow approximately 700 ft south to the New River.

SWMU 48, the oily water burial area, consists of two sets of unlined trenches, one at the northern end of the site and one at the southern end. SWMU 49, the red water ash burial no. 2, during its time of active use simply looked like an area of disturbed ground.

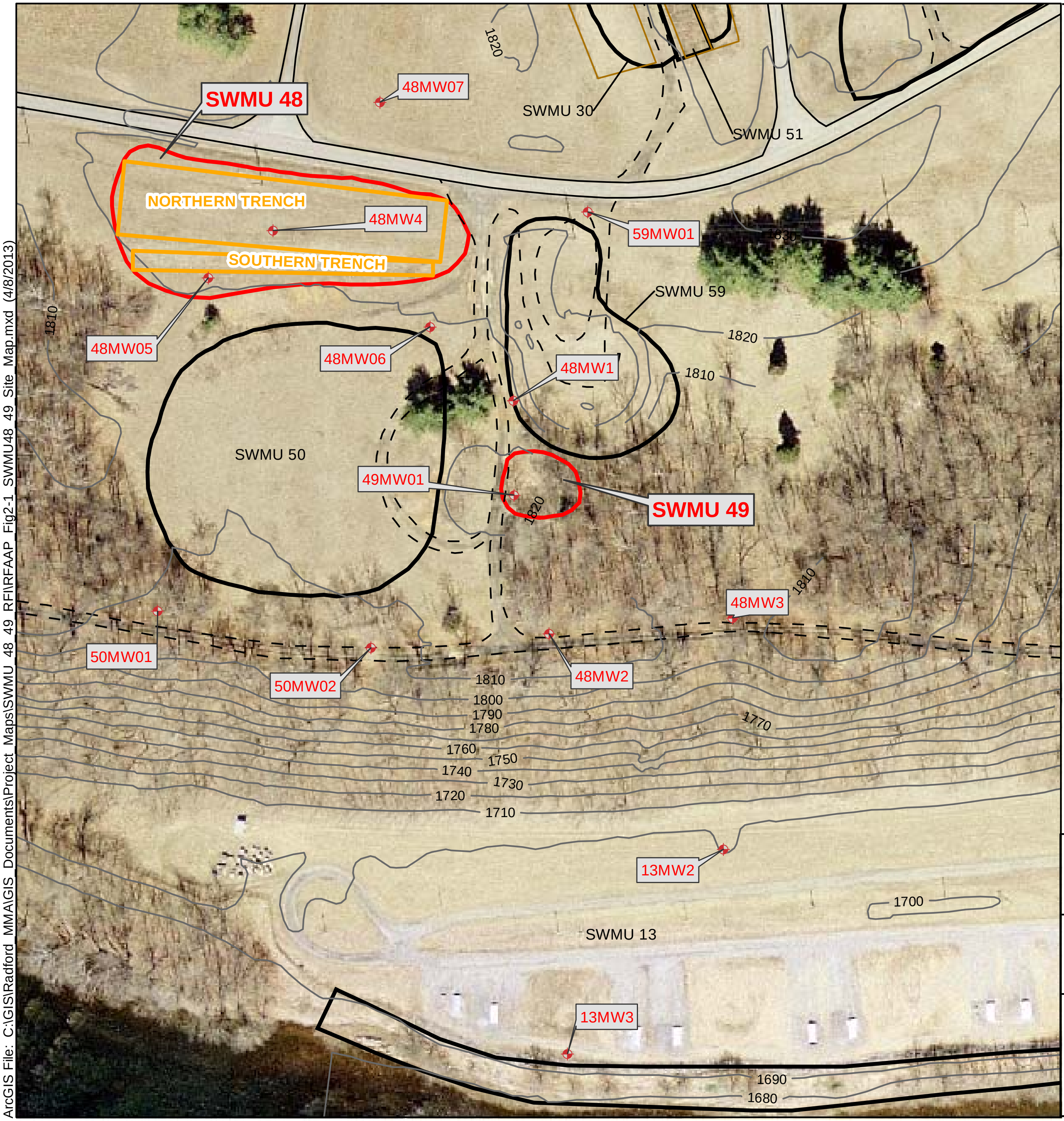
The overall study area is grassy with wooded areas to the south, east, and west. The 2000 aerial photo shown on **Figure 2-2** indicates ground scarring and disturbed soil; however, the site has revegetated in the years since they were active. A subsided area that coincides with southern SWMU 48 trench provides evidence of its location.

An east-west asphalt road, located at the northern edge of the study area, parallels SWMU 48 and provides access to the combined study area via a gravel and bottom ash covered dirt road that trends north-south in the middle of the study area. The dirt and gravel road connects to an east-west trending dirt road at the southern end of the area. There are no structures in the combined study area, and according to RFAAP utility maps, there are no manholes, catch basins, or storm drains located in the immediate vicinity of the area. There is also no sediment or surface water located on the sites.

2.2 Site History and Operations

The histories of the two SWMUs that comprise the combined study area are described separately in this section, and the site figures depict the two SWMUs as separate and distinct areas. However, it is apparent from analytical testing of soil that the combined study area should be considered as one contiguous area with some degree of cross disposal occurring when operations at the SWMUs occurred concurrently.

SWMU 48, Oily Water Burial Area. Aerial photographs taken in 1971 and 1986 indicate that SWMU 48 consists of two sets of unlined trenches, identified as the northern and southern trenches (**Figure 2-1**). Prior to off-post waste oil reclamation, approximately 200,000 gallons of oily wastewater removed from oil/water separators throughout RFAAP was reportedly disposed of in SWMU 48 (Dames and Moore, 1992). However, the results of environmental sampling to date indicate that the oily wastewater was likely disposed of in the area associated with SWMU 49. Conversely, sampling indicates that the red water ash associated with SWMU 49 was disposed in the SWMU 48 disposal trenches. Interpretations of aerial photographs indicate



ArcGIS File: C:\GIS\Radford MMA\GIS Documents\Project Maps\SWMU 48 49 RFI\RFAAP Fig2-1 SWMU48 49 Site Map.mxd (4/8/2013)

LEGEND

⌖	Monitoring Well
🟧	Trench Boundary (Identified in Previous Reports)
– – –	Dirt Road
——	Paved Road
——	Fence
——	10 ft Contour Line
🟥	SWMU 48 and SWMU 49 Boundaries
⬛	Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:
0 75 150 300
Feet

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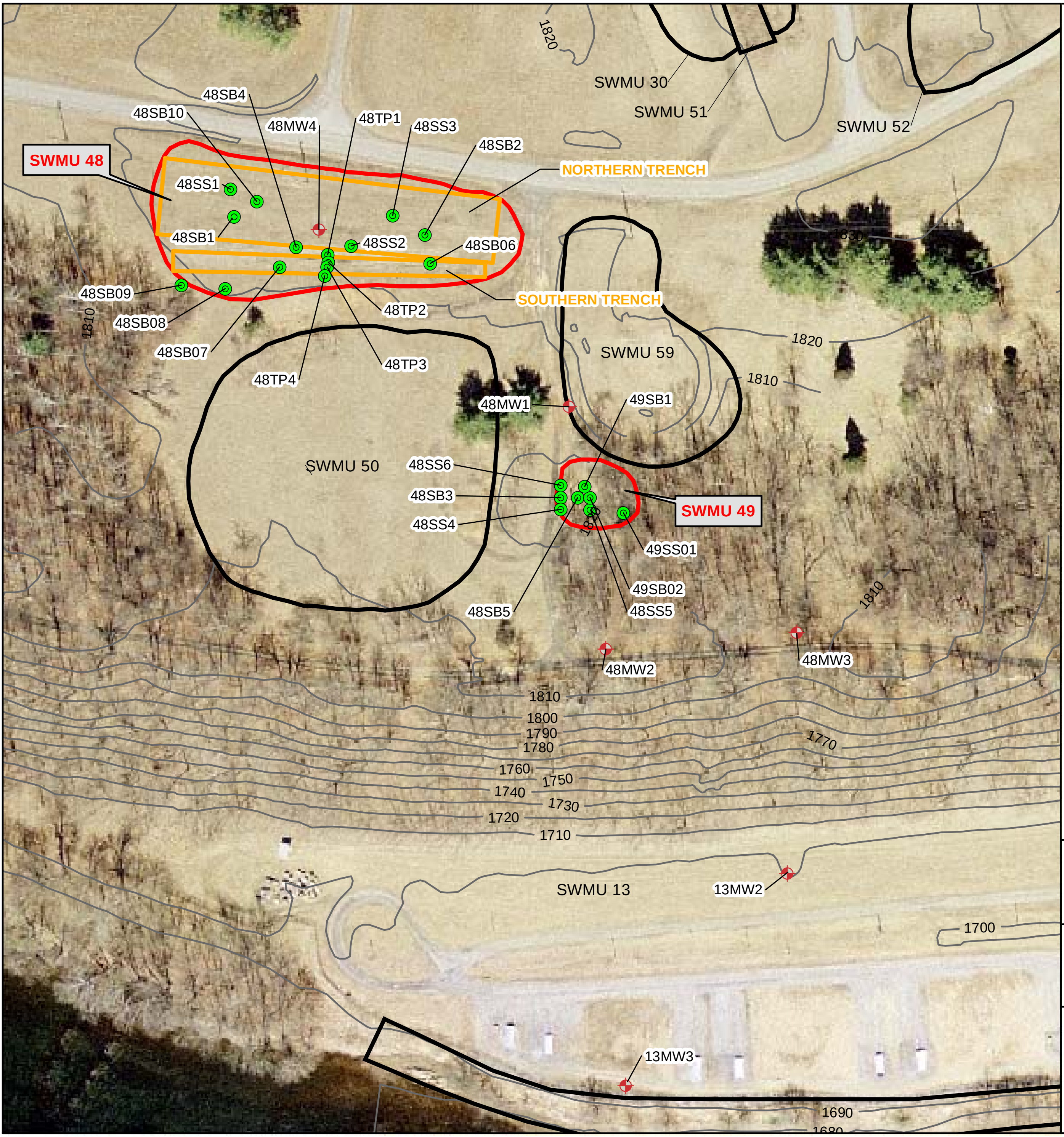
FIGURE 2-1

SWMU 48 and SWMU 49 Site Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig2-2_SWMU48_49_Previous_Sample_Locations.mxd (4/8/2013)



LEGEND

⊕ Previous Investigation Monitoring Well Location

● Previous Investigation Soil Sample Location

🟧 Trench Boundary (Identified in Previous Reports)

— 10 ft Contour Line

🟥 SWMU 48 and SWMU 49 Boundaries

⬛ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Mongomery County Planning, VA Planning & GIS Services.

N

Scale:

0 75 150 300 Feet

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FIGURE 2-2
SWMU 48 and SWMU 49
Previous Investigation Sample Locations
Radford Army Ammunition Plant,
Radford, VA

that activity first occurred at SWMU 48 in 1970 (USEPA, 1992). The northern trench is visible in the 1971 aerial photograph as light colored east to west trending scars of disturbed soil that parallel the asphalt road. Revegetation had occurred by the time of the 1981 aerial photograph. The filled and revegetated southern trench is prominent in the 1986 aerial photograph, positioned at a slight angle below the northern trench. This trench is marked by the growth of grass visibly different from the surrounding vegetation (e.g., greener and thicker) and by extensive ground subsidence. Documentation for disposal activities in the southern trench is currently unknown, but observations during soil boring and test pit activities during the 1998 RFI indicate a layer of fine black material occurring at approximately 6-7 ft below ground surface (bgs). Explosives compounds were detected in samples of this material.

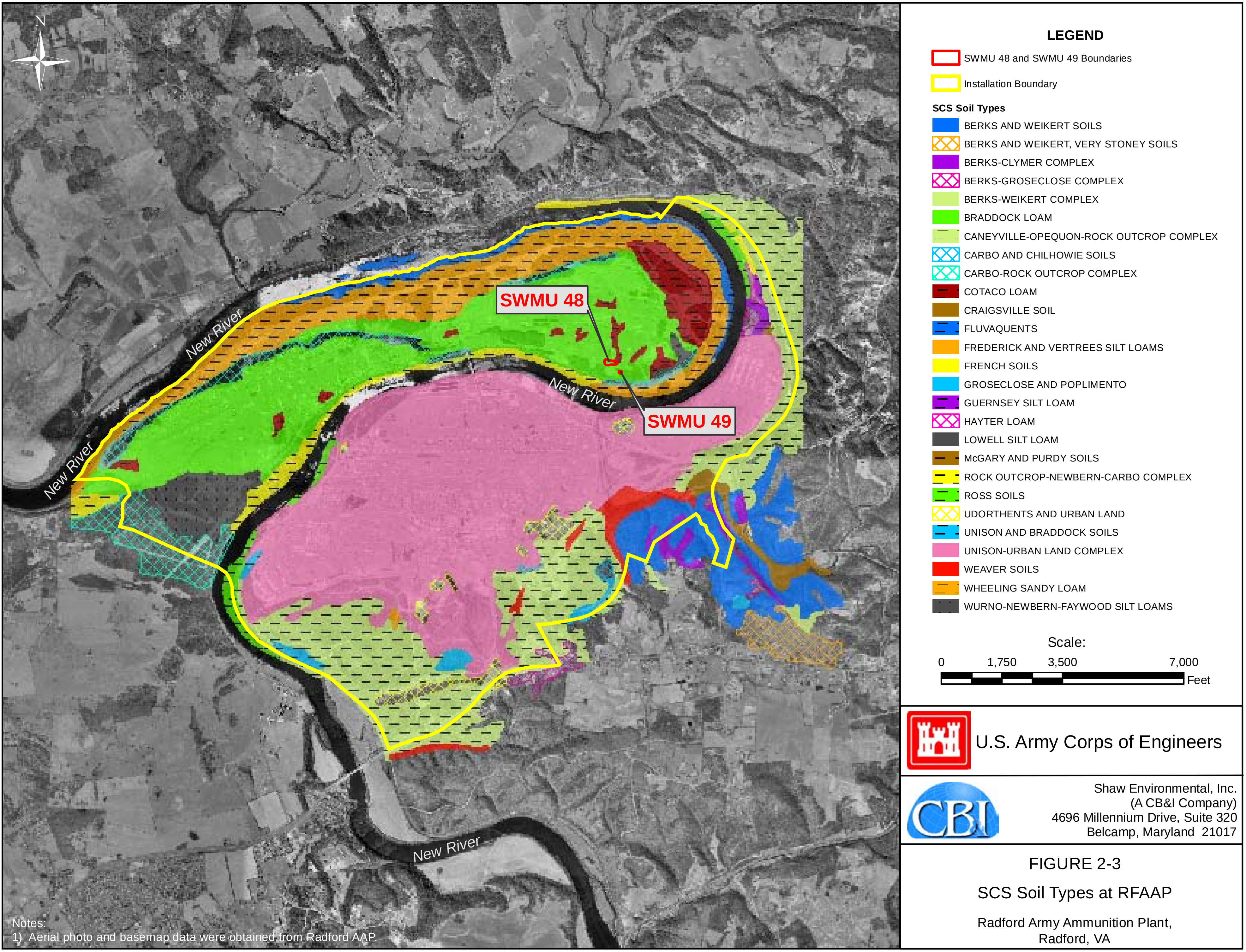
SWMU 49, Red Water Ash Burial No. 2. The location of SWMU 49 has been unclear in previous investigations, which essentially considered SWMU 49 to be contiguous or co-located with SWMU 48. In fact, previous sampling of this area was performed as part of SWMU 48 investigations. The location of SWMU 49 is defined in aerial photography by disturbed ground during the time of active disposal in the adjacent SWMUs 48 and 50. No signs of release were noted during the April 1987 visual site inspection performed during the RCRA Facility Assessment (RFA) [U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), 1987].

SWMU 49 reportedly received 10 tons of red water ash during its active period (USATHAMA, 1987). However, the results of environmental sampling to date indicate that the red water ash was likely disposed of in the disposal trenches associated with SWMU 48. Conversely, sampling indicates that the oily wastewater associated with SWMU 48 was disposed of in the SWMU 49 area. Red water ash is a USEPA listed hazardous waste (K047) and is listed solely for reactivity (40 Code of Federal Regulations 261.32). During the production and formulation of trinitrotoluene (TNT), an alkaline, red-colored aqueous waste is generated (red water). This waste stream is composed of TNT purification filtrate, air pollution control scrubber effluent, washwater from cleaning of equipment and facilities, and washwater from product washdown operations. Red water was concentrated by evaporation, and the sludge was burned in rotary kilns located in the TNT manufacturing area (USATHAMA, 1976). The ash from the burned red water sludge is known as red water ash.

2.3 Site Soil

The U.S. Department of Agriculture has mapped Braddock loam soils as underlying SWMUs 48 and 49 with slope modifiers of 2 to 7 percent, except for the small northeast corner of SWMU 48 which is a different soil type (**Figure 2-3**). A typical profile of Braddock loam has a dark yellowish-brown loam surface layer about 7 inches thick with yellowish-red and red clay subsoil extending to about 60 inches depth or more. It is a gently-sloping soil that is over 60 inches deep to bedrock and doesn’t have a seasonal high water table within 6 ft of the surface (SCS, 1985).

The soil located in the small northeast corner of SWMU 48 is defined as a Cotaco loam with slope modifiers of 2 to 7 percent. A typical profile of Cotaco loam has a 9-inch-thick brown loam surface layer with a subsoil layer extending to 60 inches or deeper. The subsoil is mainly yellowish-brown and brownish-yellow loam and clay loam and is mottled with reddish-yellow, brownish-yellow, strong brown, and light gray. Cotaco loam is a gently-sloping soil with a seasonally high water table at a depth of 1.5 to 2.5 ft and is more than 60 inches deep to bedrock. The soil type is typically found on high terraces along streams and is in irregularly shaped areas that range from 3 to 15 acres.



Notes:
1) Aerial photo and basemap data were obtained from Radford AAP.

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig2-3_SWMU48_49_MMA_SCS_Soils.mxd (4/8/2013)

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FIGURE 2-3

SCS Soil Types at RFAAP

Radford Army Ammunition Plant,
Radford, VA

2.4 Site Geology

RFAAP is located in the New River Valley, which crosses the Valley and Ridge Province approximately perpendicular to the regional strike of bedrock, and cross cuts Cambrian and Ordovician limestone or dolostone. Deep clay-rich residuum is prevalent in areas underlain by carbonate rocks. The valley floor is covered by river floodplain and terrace deposits; karst topography is dominant throughout the area.

Stratigraphic characterization of the subsurface was performed during the advancement of soil and monitoring well borings at the sites. Geologic cross-sections were developed based on the logging descriptions (**Appendix B-1**). Plan view of cross-sectional lines A-A’ and B-B’ is presented on **Figure 2-4**. As depicted on **Figures 2-5 and 2-6**, the subsurface geology consists of alluvium and residual deposits comprised of clay and silt with some sand and gravel overlying bedrock. Depth to bedrock ranges from approximately 55 to 65 ft bgs. Bedrock consists of highly fractured interbedded siltstone, limestone, and dolostone of the Elbrook Formation. The Max Meadows Breccia is evident in outcrops along the slope leading to the river. In the outcrop along the slope, the tectonic breccia and the limestone and dolostone are highly weathered with many solution cavities.

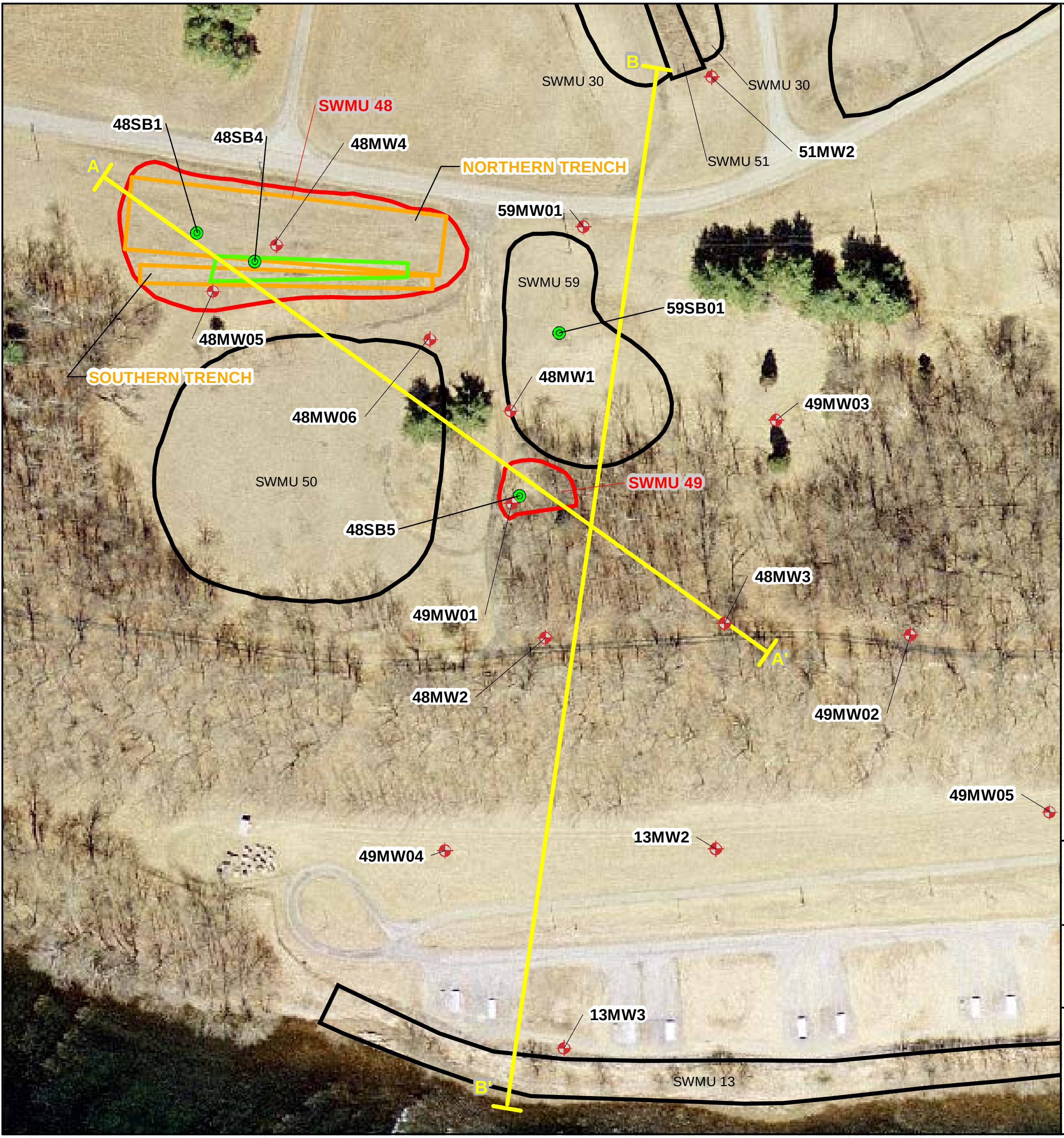
2.5 Site Hydrogeology

Groundwater conditions in the vicinity are controlled by the karstic nature of the Elbrook Formation. Based on topography and groundwater elevations measured in August 2007 and May 2013 (**Figures 2-7 and 2-8**), groundwater flow in the combined study area is to the south towards the New River and appears to follow topography. The water table becomes steeper at the southern end of the sites near the cliff above SWMU 13 and the New River. As discussed in *Section 3.4*, four new monitoring wells were installed to the south and east of SWMUs 48 and 49 during the 2013 Supplemental RFI to refine the understanding of groundwater flow in the combined study area and better define the extent of chlorinated solvents previously detected in groundwater.

The groundwater table was present below the sites in August 2007 at elevations ranging from 1694.41 to 1786.86 ft msl (**Figure 2-7**) and from 1680.17 to 1757.13 ft msl in May 2013 (**Figure 2-8**). A steep hill exists between SWMU 49 and SWMU 13 and, therefore, no monitoring wells are positioned between these sites. As discussed in *Section 2.1*, surface water is also expected to flow towards the New River.

2.6 Previous Investigations

Six previous investigations have been conducted at SWMUs 48 and 49. In 1987, USEPA conducted an RFA to evaluate potential hazardous waste or hazardous constituent releases and implement corrective actions, as necessary. In 1992, Dames and Moore performed a Verification Investigation (VI), which included surface and subsurface soil sampling and a soil gas survey to characterize the nature and extent of contamination. In 1996, Parsons Engineering Science conducted an RFI to further delineate the extent of contamination identified during the 1992 VI sampling. ICF Kaiser Engineers also performed an RFI in 1998 to further refine the understanding of the nature and extent of contamination identified during the previous investigations. Additional sampling was conducted by IT Corporation/Shaw in 2002 and 2006 to collect sufficient data to complete human health and ecological risk assessments. These investigations and results of the chemical data are summarized below.



LEGEND

⊕ Monitoring Well

◎ Previous Investigation Soil Sample Location

— Geologic Cross Section Line

🟩 Southern Trench Boundary (GPS)

🟧 Trench Boundary (Identified in Previous Reports)

🟥 SWMU 48 and SWMU 49 Boundaries

⬛ Other SWMU Boundaries

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA GIS & Planning Services.

N

Scale:
0 80 160 320
Feet

U.S. Army Corps of Engineers

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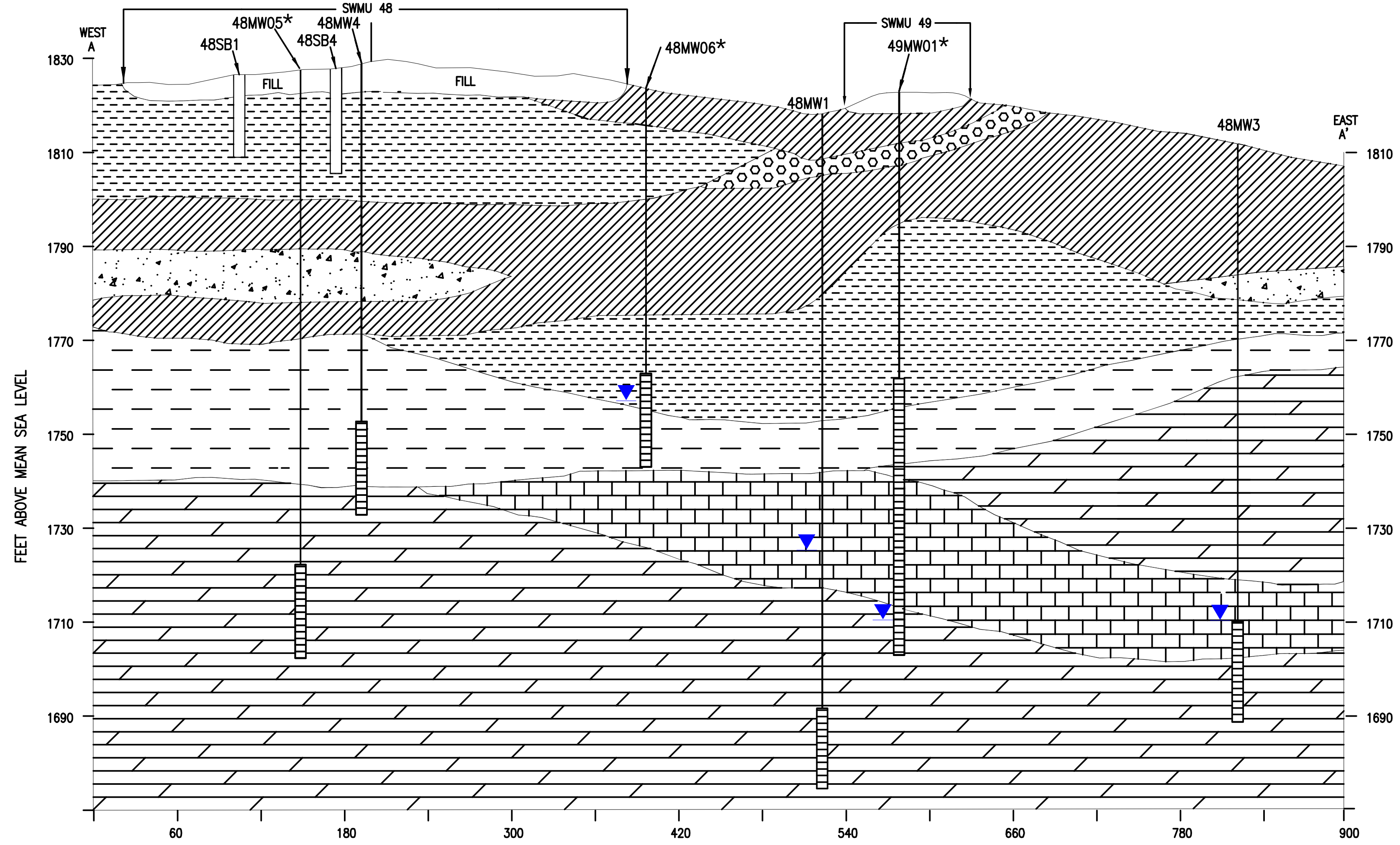
FIGURE 2-4
SWMU 48 and SWMU 49
Geologic Cross Sections Plan View
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig2-4_SWMU48_49_XSect.mxd (11/6/2013)



LEGEND

- ▤ CLAY AND SILT, LITTLE SAND, RED-BROWN (CL)
- ▨ SILT, SOME SAND, SOME CLAY, ORANGE-BROWN (ML)
- ○ SILT AND SAND, GRAVEL ORANGE-BROWN (CM/SM)
- ⁖ SILT, SAND, AND GRAVEL, ORANGE-BROWN (GM)
- ▭ SILTSTONE, WEATHERED RED, GREEN, BROWN, INTERBEDDED DOLOMITE (SLSN)
- ▤ DOLOMITE, WEATHERED, GRAY, ARGILLACEOUS (DLMT)
- ▦ LIMESTONE, GRAY-BROWN, ARGILLACEOUS (LMSN)
- ▼ STATIC GROUNDWATER LEVEL (MEASURED MAY 2013)
- * PROJECTED LOCATION

SOURCE: PARSONS ENGINEERING SCIENCE, INC.

NOTES

1) SOME DATA POINTS ARE PROJECTED ONTO PROFILE.

2) 48SB1 AND 48SB2 LITHOLOGY FROM DAMES AND MOORE.

3) LITHOLOGY PATTERNS DO NOT MATCH DRILL LOG PATTERS BECAUSE OF DIFFERING GRAPHICS SYSTEMS.

4) CONTACT LINES DASHED WHERE INFERRED.

5) LITHOLOGY IS A COMPILATION FROM SWMUs 48 AND 49.

HORIZ. SCALE: 0 60 120

VERT. SCALE: 0 20 40

RADFORD AAP

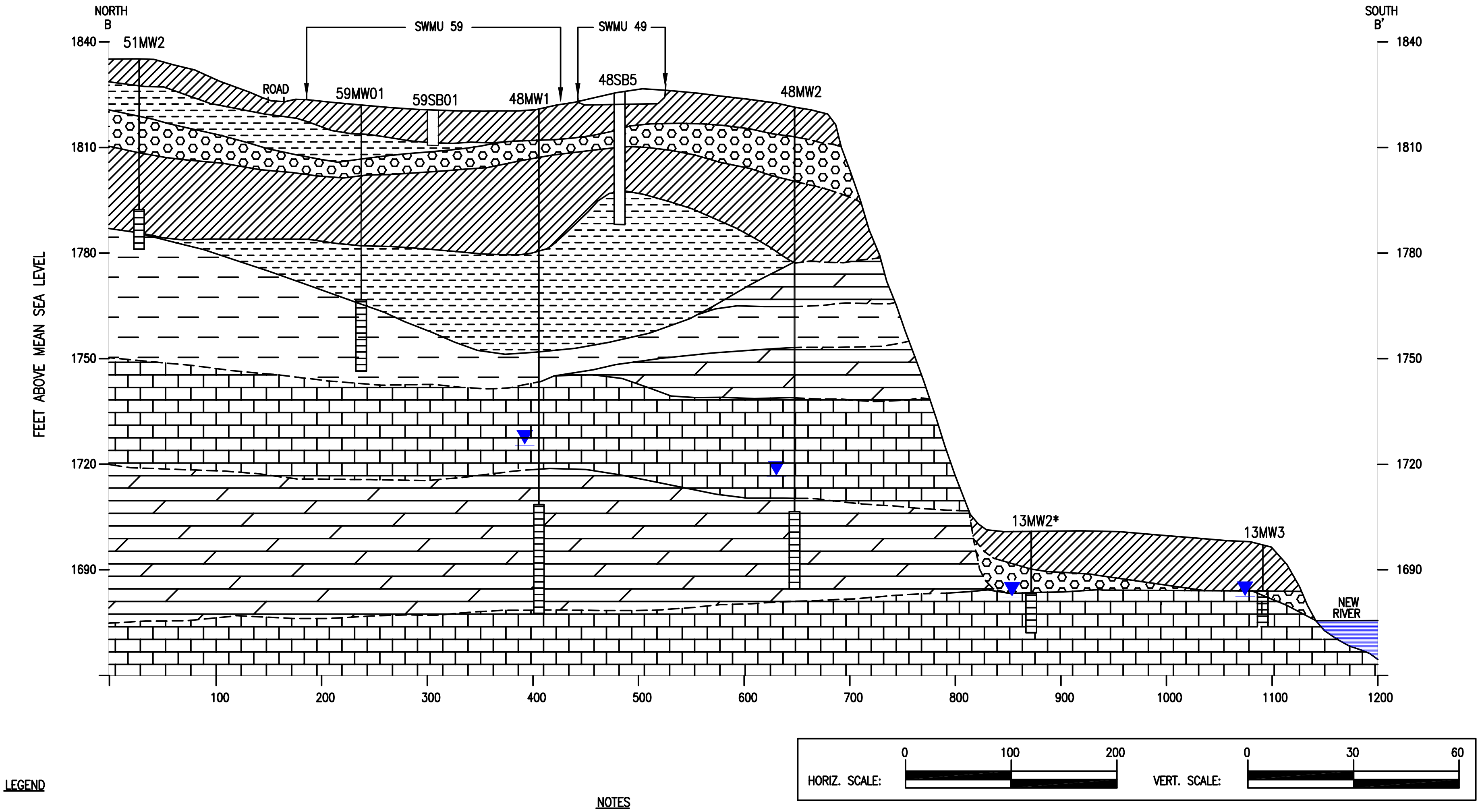
PREPARED BY: SHAW
CHECKED BY: M. Thomas
DATE: NOV. 2013

TASK NO: 12346121003000
SHAW DWG NO: FIG2-5.dwg

FIGURE 2-5

GEOLOGIC
CROSS-SECTION A-A'
SWMUs 48 AND 49

File: O:\Shaw Offices – CAD Files\Edgewood, MD\123461\SWMU 48 49 50 and 59 RFI\Fig 2-6 SWMU 48 and 49 11-7-13.dwg
Plot Date/Time: Nov 07, 2013 – 3:35pm
Plotted By: bernadette.oconnor



LEGEND

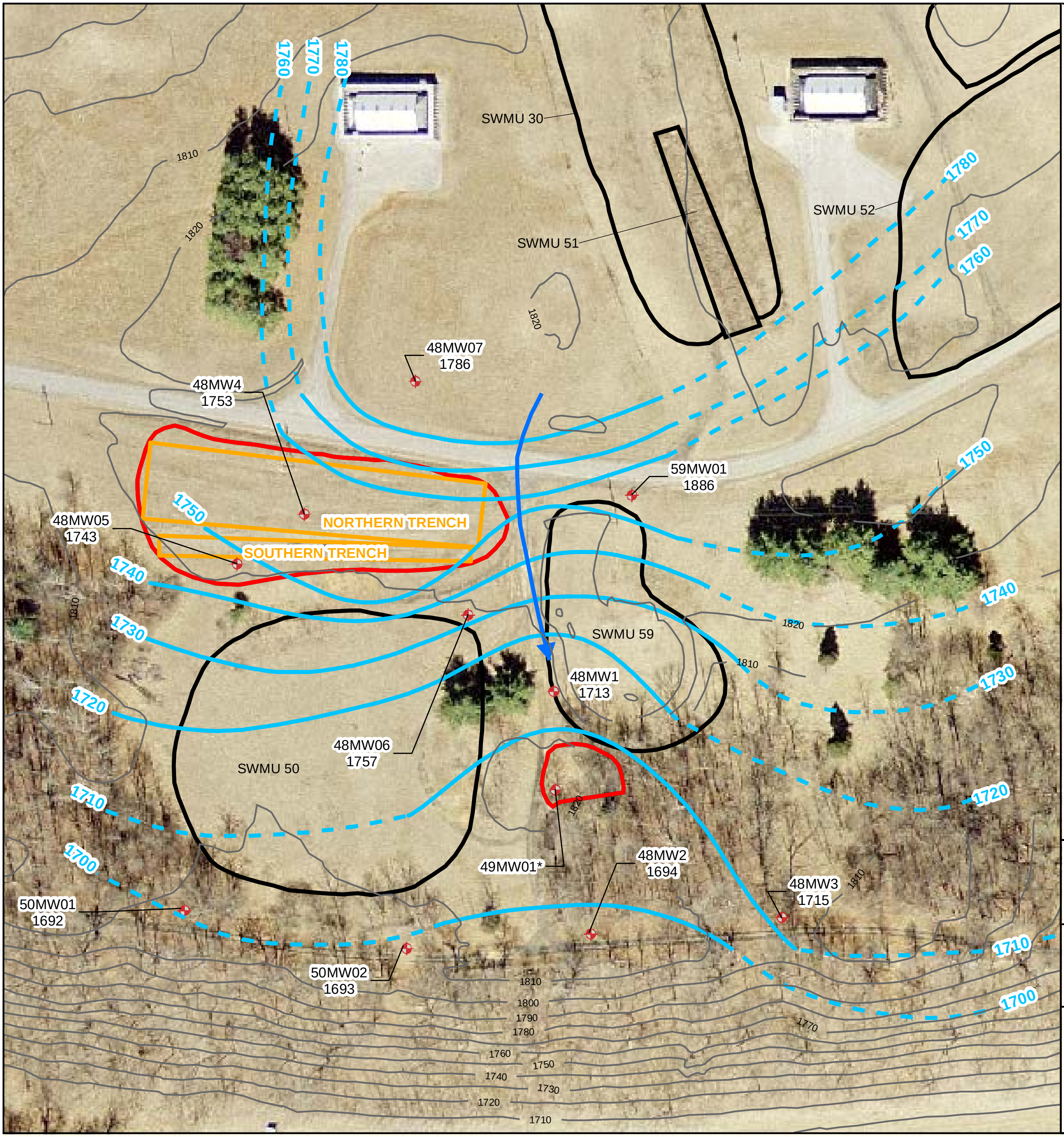
- ┄ CLAY AND SILT, LITTLE SAND, RED-BROWN (CL)
- ▨ SILT, SOME SAND, SOME CLAY, ORANGE-BROWN (ML)
- ○ SILT AND SAND, GRAVEL ORANGE-BROWN (CM/SM)
- ⁘ SILT, SAND, AND GRAVEL, ORANGE-BROWN (GM)
- ─ SILTSTONE, WEATHERED RED, GREEN, BROWN, INTERBEDDED DOLOMITE (SLSN)
- ▤ DOLOMITE, WEATHERED, GRAY, ARGILLACEOUS (DLMT)
- ▦ LIMESTONE, GRAY-BROWN, ARGILLACEOUS (LMSN)
- ▼ STATIC GROUNDWATER LEVEL (MEASURED MAY 2013)

NOTES

1) SOME DATA POINTS ARE PROJECTED ONTO PROFILE.
2) 51MW2 AND 13MW2 LITHOLOGY FROM DAMES AND MOORE.
3) LITHOLOGY PATTERNS DO NOT MATCH DRILL LOG PATTERNS BECAUSE OF DIFFERING GRAPHICS SYSTEMS.
4) CONTACT LINES DASHED WHERE INFERRED.
5) ADDITIONAL WELLS SHOWN TO AID IN CROSS-SECTION ACCURACY.

SOURCE: PARSONS ENGINEERING SCIENCE, INC.

RADFORD AAP		FIGURE 2-6
PREPARED BY: SHAW	TASK NO: 12346110000002	GEOLOGIC CROSS-SECTION B-B' SWMUs 48 AND 49
CHECKED BY: MT	SHAW DWG NO: FIG 2-6.dwg	
DATE: REVISED NOV 2013		



ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig2-7_SWMU48_49_Potentiometric_Surface_Aug_2007.mxd (10/16/2013)

LEGEND

⊕	Groundwater Sample Location
- - -	Inferred Groundwater Contour
—	Groundwater Contour
→	Groundwater Flow Direction
—	10 ft Contour Line
▭	Trench Boundary (Identified in Previous Reports)
▭	SWMU 48 and SWMU 49 Boundaries
▭	Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Water levels are expressed in feet above mean sea level.
3) All water levels were measured in August, 2007.
4) * = Well 49MW01 was essentially dry and not used in determining the potentiometic surface.

N

Scale:

0 75 150 300 Feet

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FIGURE 2-7
Combined Study Area
Potentiometric Surface Map - August 2007
Radford Army Ammunition Plant,
Radford, VA

LEGEND

⌖ Monitoring Well

— 10 ft Contour Line

- - Inferred Groundwater Contour

— Groundwater Contour

→ Groundwater Flow Direction

🟥 SWMU 48 and 49 Boundaries

☐ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Groundwater elevation values are in feet.
3) Groundwater flow direction is dashed where inferred.

N

Scale:

0 125 250 500 Feet

U.S. Army Corps of Engineers

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FIGURE 2-8
Combined Study Area
Potentiometric Surface Map - May 2013

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford MMA\GIS Documents\Project Maps\SWMU 48 49 RFI\RFAAP Fig2-8 SWMU48 49 Potentiometric Surface May 2013.mxd (11/11/2013)

2.6.1 RFA, USEPA, 1987

An installation-wide assessment was conducted for RFAAP to evaluate potential hazardous waste or hazardous constituent releases and implement corrective actions, as necessary. The assessment consisted of a preliminary review and evaluation of available site information, personnel interviews, and a visual site inspection. Environmental samples were not collected from SWMUs 48 or 49 as part of the inspection.

The assessment indicated that inactive SWMUs 48 and 49 are contiguous, and no distinction can be made by visual observation. During a site inspection in April 1987, there were no visual signs of release; however, some residue of what appeared to be calcium sulfate was noted, likely associated with adjacent SWMU 50 – Calcium Sulfate Treatment/Disposal Area.

2.6.2 VI, Dames and Moore, 1992

The VI report was prepared for USATHAMA and covered many RFAAP SWMUs. The objective was to evaluate whether toxic or hazardous contaminants are present and are, or have the potential of, migrating beyond the boundaries of the identified SWMUs. Environmental samples were collected, analyzed for chemical constituents, and evaluated. Recommendations for further study or action (or No Further Action) were made. Environmental samples collected from the SWMU 48/49 combined study area included:

- Two soil samples from within [48SB1(RVFS*1) and 48SB2(RVFS*3)] and two samples below disposed material at SWMU 48 [48SB1(RVFS*2) and 48SB2(RVFS*4)], analyzed for target analyte list (TAL) metals, toxicity characteristic leachate procedure (TCLP) metals, volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs).
- One soil sample [48SB3(RVFS*6)] from a depth of 18-20 ft at SWMU 49, analyzed for TAL metals, TCLP metals, VOCs, and SVOCs.
- In addition, due to detections of SVOCs in soil and apparent fuel-like odors encountered from 13 to 22 ft in the soil boring from SWMU 49, a subsurface soil gas survey was conducted over a 100-ft x 100-ft area. Eight soil gas samples were collected at 50-ft spacing from a depth of 4 ft bgs and analyzed for pentane/methyl tert-butyl ether, benzene, toluene, ethylbenzene, and xylenes. Concentrations were at or below detectable levels. Soil gas survey procedures and results can be found in **Appendix B-2**.

A summary of VI sampling is included in **Table 2-1**. Positive detections for VI sampling and detections above screening levels (SLs) for SWMUs 48 and 49 are identified in **Tables 2-2 and 2-3**, respectively. Detailed discussion of detections above SLs will be presented in *Section 4.0*. Soil sampling locations are depicted on **Figure 2-2**. It should be noted that SWMU 49 was not distinguished in the report separately from SWMU 48. The area now considered to be SWMU 49 was sampled and discussed as “the lower disposal area” of SWMU 48. Therefore, samples from SWMU 49 were identified with a “48” prefix.

Table 2-1
Previous Investigations Samples and Analyses

Media	Sample ID	Depth (ft bgs)	Analyses
SWMU 48			
1992 Verification Investigation, Dames & Moore			
Subsurface Soil	48SB1	7.5-9.5	TAL metals, VOCs, SVOCs, TCLP metals
	48SB1	13-15	TAL metals, VOCs, SVOCs, TCLP metals
	48SB2	10-12	TAL metals, VOCs, SVOCs, TCLP metals
	48SB2	20-22	TAL metals, VOCs, SVOCs, TCLP metals
1996 RCRA Facility Investigation, Parsons Engineering Science, Inc.			
Surface Soil	48SS1	0-1	TAL metals, VOCs, SVOCs, explosives, TPH
	48SS2	0-1	TAL metals, VOCs, SVOCs, explosives, TPH
	48SS3	0-1	TAL metals, VOCs, SVOCs, explosives, TPH
Subsurface Soil	48SB4A11	10-11	VOCs, SVOCs, explosives, TPH
	48SB4B21	20-21	VOCs, SVOCs, explosives, TPH, TOC
1998 RCRA Facility Investigation, ICF Kaiser Engineers, Inc.			
Surface Soil	48SB6C	1-3	TAL metals, VOCs, SVOCs, PAHs, explosives
	48SB6C2	1-3	VOCs (methanol preservation)
Subsurface Soil	48SB6A	6-7	TAL metals, VOCs, SVOCs, PAHs, explosives
	48SB6A2	6-7	VOCs (methanol preservation)
	48SB6B	14-16	TAL metals, VOCs, SVOCs, PAHs, explosives
	48SB6B2	14-16	VOCs (methanol preservation)
	48SB7A	8-9	TAL metals, VOCs, SVOCs, PAHs, explosives
	48SB7A2	8-9	VOCs (methanol preservation)
	48SB7B	10-11	TAL metals, VOCs, SVOCs, PAHs, explosives
	48TP1	6-6.5	TAL metals, VOCs, SVOCs, PAHs, explosives
	48TP2	6-6.5	TAL metals, VOCs, SVOCs, PAHs, explosives
	48TP3	6-6.5	TAL metals, VOCs, SVOCs, PAHs, explosives
	48TP4	6-6.5	TAL metals, VOCs, SVOCs, PAHs, explosives
2002 Site Characterization, IT Corporation			
Surface Soil	48SB08A	0-0.5	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans, TOC, grain size, pH
	48SB09A	0-0.5	Explosives, dioxins/furans
	48SB10A	0-0.5	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans
Subsurface Soil	48SB08B	4-6	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	48SB08C	8-10	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans, TOC, grain size, pH
	48SB09B	4-6	Explosives, dioxins/furans
	48SB09C	8-10	Explosives, dioxins/furans
	48SB10B	4-6	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans
	48SB10C	8-10	TCL VOCs, SVOCs, PCBs, PAHs, explosives, TAL metals, dioxins/furans

Table 2-1 (Continued)
Previous Investigations Samples and Analyses

Media	Sample ID	Depth (ft bgs)	Analyses
SWMU 49			
1992 Verification Investigation, Dames and Moore			
Subsurface Soil	48SB3	10-12	TAL metals, VOCs, SVOCs, TCLP metals
1996 RCRA Facility Investigation, Parsons Engineering Science, Inc.			
Surface Soil	48SS4	0-1	TAL metals, SVOCs, TPH
	48SS5	0-1	TAL metals, SVOCs, TPH
	48SS6	0-1	TAL metals, SVOCs, TPH
Subsurface Soil	48SB5A19	17-19	SVOCs, TPH
	48SB5B37	35-37	SVOCs, TPH, TOC
	48MW1A22	20-22	SVOCs, TPH
	48MW1B54	52-54	SVOCs, TPH, TOC
	48MW2A42	40-42	SVOCs, TPH
	48MW2B46	44-46	SVOCs, TPH, TOC
	48MW3A22	20-22	SVOCs, TPH
	48MW3B32	30-32	SVOCs, TPH, TOC
1998 RCRA Facility Investigation, ICF Kaiser Engineers, Inc.			
Subsurface Soil	49SB1A	8-10	TAL metals, VOCs, SVOCs, PAHs, explosives
	49SB1B	18-24	TAL metals, VOCs, SVOCs, PAHs, explosives
	49SB1B2	18-24	VOCs (methanol preservation)
	49SB1C	28-32	TAL metals, VOCs, SVOCs, PAHs, explosives
	49SB1C2	28-32	VOCs (methanol preservation)
	49SB1D	38-40	TAL metals, VOCs, SVOCs, PAHs, explosives
	49SB1D2	38-40	VOCs (methanol preservation)
	49SB1E	48-50	TAL metals, VOCs, SVOCs, PAHs, explosives
	49SB1F	58-60	TAL metals, VOCs, SVOCs, PAHs, explosives
2002 Site Characterization, IT Corporation			
Surface Soil	49SS01	0-0.5	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans, TOC, grain size, pH
	49SB02A	0-0.5	TCL VOCs, SVOCs, pesticides/PCBs, herbicides, PAHs, explosives, TAL metals, dioxins/furans
Subsurface Soil	49SB02B	4-6	TCL PCBs, PAHs, TAL metals, dioxins/furans
	49SB02C	8-10	TCL PCBs, PAHs, TAL metals, dioxins/furans
	49SSB02D	17-19	TCL PCBs, PAHs, TAL metals, dioxins/furans, TPH, TOC, grain size, pH

Table 2-1 (Continued)
Previous Investigations Samples and Analyses

Media	Sample ID	Depth (ft bgs)	Analyses
Combined Study Area Groundwater Assessment			
1996 RCRA Facility Investigation, Parsons Engineering Science, Inc.			
Groundwater	48MW1	na	TAL metals, VOCs, SVOCs, Hardness, TPH, TOC, TOX, Chloride
	48MW1	na	TAL metals, VOCs, SVOCs, Hardness, TOC, TOX, Chloride
	48MW2	na	TAL metals, VOCs, SVOCs, Hardness, TPH, TOC, TOX, Chloride
	48MW2-Diss	na	TAL metals, VOCs, SVOCs, Hardness, TOC, TOX, Chloride
	48MW3	na	TAL metals, VOCs, SVOCs, Hardness, TPH, TOC, TOX, Chloride
	48MW3-Diss	na	TAL metals, VOCs, SVOCs, Hardness, TOC, TOX, Chloride
	48MW4	na	TAL metals, VOCs, SVOCs
	48MW4-Diss	na	TAL metals, VOCs, SVOCs
1998 RCRA Facility Investigation, ICF Kaiser Engineers, Inc.			
Groundwater	48MW1-2	na	TAL metals, VOCs, SVOCs, PAHs, explosives, TOC, TOX
	48MW2-2	na	TAL metals, VOCs, SVOCs, PAHs, explosives, TOC, TOX
	48MW3-2	na	TAL metals, VOCs, SVOCs, PAHs, explosives, TOC, TOX
	48MW4-2	na	TAL metals, VOCs, SVOCs, PAHs, explosives, TOC, TOX
2006 Eastern Horseshoe Area GW Sampling, Shaw			
Groundwater	48MW1	na	TAL metals, TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, dioxins/furans
	48MW2	na	TAL metals, TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, dioxins/furans
	48MW3	na	TAL metals, TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, dioxins/furans
	48MW4	na	TAL metals, TCL VOCs, SVOCs, PAHs, pest/PCBs, explosives, dioxins/furans

Table 2-2
Analytes Detected in SWMU 48 Soil Samples - 1992 VI

Analyte			Sample ID	**48SB1 (RVFS*1)**			**48SB1 (RVFS*2)**			**48SB2 (RVFS*3)**			**48SB2 (RVFS*4)**		
			Sample Date	**8/19/91**			**8/19/91**			**8/16/91**			**8/16/91**		
			Sample Depth	**7.5-9.5**			**13-15**			**10-12**			**20-22**		
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q
VOCs (ug/kg)															
Toluene	4500000	500000	na	0.78	U	U	0.78	U	U	1			0.78	U	U
SVOCs (ug/kg)															
2,4-Dinitrotoluene	5500	1600	na	700	U	U	140	U	U	3200			140	U	U
2,6-Dinitrotoluene	62000	6100	na	400	U	U	85	U	U	1200			85	U	U
bis(2-Ethylhexyl)phthalate	120000	35000	na	3000	U	U	620	U	U	1000			620	U	U
Di-n-butylphthalate	6200000	610000	na	300	U	U	61	U	U	2900			190		
Naphthalene	18000	3600	na	200	U	U	37	U	U	270			37	U	U
Phenanthrene	1700000	170000	na	200			33	U	U	130			33	U	U
Pyrene	1700000	170000	na	300			33	U	U	33	U	U	33	U	U
Metals (mg/kg)															
Aluminum	99000	7700	40041	2940			12200			15700			14600		
Arsenic	1.6	0.39	15.8	8.19			3.1			4.7			2.75		
Barium	19000	1500	209	42.5			36.7			52.4			70.8		
Beryllium	200	16	1.02	0.767			**1.73**			**2.15**			**4.98**		
Calcium	na	na	na	240000			662			9740			198		
Chromium	150000	12000	65.3	7.78			27.3			29.5			31.9		
Cobalt	30	2.3	72.3	3.01			6.34			11.3			17.9		
Copper	4100	310	53.5	10.8			6.87			**135**			14.6		
Iron	72000	5500	50962	8550			21200			25800			41600		
Lead	800	400	26.8	**36.9**			10.5	U	U	**154**			10.5	U	U
Magnesium	na	na	na	130000			784			3390			763		
Manganese	2300	180	2543	222			195			278			547		
Mercury	4.3	1.0	0.13	**2.6**			0.05	U		**0.23**			0.05	U	
Nickel	2000	150	62.8	4.91			6.57			25.6			24.5		
Potassium	na	na	na	327			551			758			934		
Silver	510	39	na	1.03			0.589	U	U	0.855			0.589	U	U
Sodium	na	na	na	551			372			391			2880		
Vanadium	520	39	108	8.97			30			34.3			32.8		
Zinc	31000	2300	202	38.2			23			71.3			29.8		

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-2
Legend

12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
U = Analyte not detected.

Table 2-3
Analytes Detected in SWMU 49 Soil Samples - 1992 VI

Analyte			Sample ID	**48SB3 (RVFS*6)**		
			Sample Date	**8/19/91**		
			Sample Depth	**18-20**		
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q
VOCs (ug/kg)						
Ethylbenzene	27000	5400	na	47		
Toluene	4500000	500000	na	2.6		
Xylenes (total)	270000	63000	na	250		
SVOCs (ug/kg)						
2-Methylnaphthalene	410000	31000	na	30000		
Fluorene	2200000	230000	na	8000		
Naphthalene	18000	3600	na	6000		
Phenanthrene	1700000	170000	na	10000		
Metals (mg/kg)						
Aluminum	99000	7700	40041	16400		
Barium	19000	1500	209	32.5		
Beryllium	200	16	1.02	**<u>2.98</u>**		
Chromium	150000	12000	65.3	13.2		
Cobalt	30	2.3	72.3	25.6		
Copper	4100	310	53.5	3		
Iron	72000	5500	50962	23700		
Magnesium	na	na	na	751		
Manganese	2300	180	2543	168		
Nickel	2000	150	62.8	30.8		
Potassium	na	na	na	1890		
Sodium	na	na	na	315		
Vanadium	520	39	108	16.8		
Zinc	31000	2300	202	23.8		

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-3
Legend

12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
µg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.

The VI report concluded that contaminants of concern included:

- Explosive SVOC compounds (DNT-mix) were detected within SWMU 48 that were greater than health-based numbers. However, the report also noted that the explosives were not detected in the deeper soil sample, indicating that downward migration had not occurred and impact to groundwater was unlikely.
- SVOCs deep in the soil column at SWMU 49 which created the potential for groundwater contamination.

The report recommended further sampling and/or an RFI to address the source and extent of the contaminants of concern identified.

2.6.3 RFI, Parsons Engineering Science, 1996

The 1996 RFI was performed for the U.S. Army Environmental Command (USAEC) (formerly USATHAMA) to support the Permit for Corrective Action and Incinerator Operation at RFAAP. The RFI was initiated to characterize the nature, extent, and potential migration of releases of hazardous waste or hazardous constituents from SWMUs 17, 31, 48 (at the time, SWMU 49 was still considered part of SWMU 48), and 54.

The following environmental samples were collected from SWMUs 48 and 49:

- Six surface soil samples; three from SWMU 48 (48SS1, 48SS2, and 48SS3) and three from SWMU 49 (48SS4, 48SS5, and 48SS6). Samples were analyzed for metals, SVOCs, and total petroleum hydrocarbons (TPH); SWMU 48 samples were also analyzed for VOCs and explosives.
- Two subsurface soil samples from each of two soil borings [one boring in SWMU 48 (samples 48SB4A11 and 48SB4B21) and one boring in SWMU 49 (samples 48SB5A19 and 48SB5B37)]. Samples were analyzed for SVOCs and TPH; SWMU 48 samples were also analyzed for VOCs and explosives.
- Two subsurface soil samples from each of four well borings. Samples were analyzed for SVOCs and TPH. SWMU 48 samples were also analyzed for VOCs and explosives.
- Four groundwater samples from new monitoring wells. At SWMU 49, samples were analyzed for metals, VOCs, SVOCs, and TPH.

A summary of sampling for the 1996 RFI is included in **Table 2-1**, and chemical results from the samples are presented in **Tables 2-4 and 2-5** (soil) as well as **Table 2-6** (groundwater). Detailed discussion of detections above SLs will be presented in *Section 4.0*. Soil sampling locations are located on **Figure 2-2**. As with the VI sampling, the area now considered to be SWMU 49 was sampled and discussed as “the lower disposal area” of SWMU 48. Therefore, samples from SWMU 49 were identified with a “48” prefix.

The draft RFI report, submitted in January 1996, included an HHRA and identified the following risk drivers:

- Surface Soil – Arsenic and beryllium.
- Subsurface Soil – Not considered in the risk assessment because samples were collected from greater than 10 ft bgs.
- Groundwater – Beryllium and carbon tetrachloride (CT).

Table 2-4
Analytes Detected in SWMU 48 Soil Samples - 1996 RFI

Analyte			Sample ID	**48SB4A11**			**48SB4B21**			**48SS1**			**48SS2**			**48SS3**		
			Sample Date	**12/17/94**			**12/17/94**			**12/16/94**			**12/16/94**			**12/16/94**		
			Sample Depth	**10-11**			**20-21**			**0-0.5**			**0-0.5**			**0-0.5**		
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q
VOCs (ug/kg)	None detected																	
SVOCs (ug/kg)																		
bis(2-Ethylhexyl)phthalate	120000	35000	na	2800			3600			1500			1300			480	U	U
Chrysene	210000	15000	na	32	U	U	32	U	U	86			32	U	U	32	U	U
Di-n-butylphthalate	6200000	610000	na	1300	U	U	6000			1300	U	U	10000			1300	U	U
N-nitrosodiphenylamine	350000	99000	na	1400			1700			290	U	U	290	U	U	290	U	U
Phenanthrene	1700000	170000	na	32	U	U	32	U	U	270			32	U	U	32	U	U
Explosives (mg/kg)	None detected																	
Metals (mg/kg)																		
Arsenic	1.6	0.39	15.8	NT			NT			3.42			7.97			2.5	U	U
Barium	19000	1500	209	NT			NT			**572**			82.3			108		
Beryllium	200	16	1.02	NT			NT			**1.62**			0.739			0.872		
Chromium	150000	12000	65.3	NT			NT			5.34			47.8			24.3		
Lead	800	400	26.8	NT			NT			4.4			**160**			18		
Mercury	4.3	1.0	0.13	NT			NT			1.11			**0.441**			0.05	U	U
Nickel	2000	150	62.8	NT			NT			8.93			25.4			6.13		
Selenium	510	39	na	NT			NT			0.449	U	U	1.07			0.449	U	U
Silver	510	39	na	NT			NT			0.0124	U	U	0.0285			0.0245		
Misc. (mg/kg)																		
TPH	100	100	na	10	U		10	U		10	U		10	U		10	U	

* Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-4
Legend

12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
TPH screening values are based on the VDEQ Storage Tank Program action levels
mg/kg = milligrams per kilogram (parts per million).
µg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
U = Analyte not detected.

Table 2-5
Analytes Detected in SWMU 49 Soil Samples - 1996 RFI

Analyte			Sample ID	48MW3A22			48MW3B32			48MW1A22			48MW1B54			48MW2A42			48MW2B46			48SB5A19			48SB5B37			48SS4			48SS5			48SS6		
			Sample Date	1/7/95			1/7/95			12/17/94			12/18/94			12/20/94			12/20/94			12/17/94			12/17/94			12/16/94			12/16/94			12/16/94		
			Sample Depth	20-22			30-32			20-22			52-54			40-42			8270C-8270C			17-19			35-37			0-0.5			0-0.5			0-0.5		
	i-SL	r-SL	Background	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q
VOCs (ug/kg)	Samples were not tested for this group.																																			
SVOCs (ug/kg)																																				
bis(2-Ethylhexyl)phthalate	120000	35000	na	3100			2000			6400			5300			1700			480	U	U	40000			10000			480	U	U	480	U	U	1200		
Chrysene	210000	15000	na	32	U	U	32	U	U	32	U	U	32	U	U	32	U	U	32	U	U	200	U	U	32	U	U	79			32	U	U	70		
Di-n-butylphthalate	6200000	610000	na	1900			1300	U	U	1300	U	U	1300	U	U	1300	U	U	1300	U	U	6000	U	U	1300	U	U	1300	U	U	1300	U	U	1300	U	U
Naphthalene	18000	3600	na	740	U	U	740	U	U	740	U	U	740	U	U	740	U	U	740	U	U	20000			740	U	U	740	U	U	740	U	U	740	U	U
Phenanthrene	1700000	170000	na	32	U	U	32	U	U	32	U	U	32	U	U	32	U	U	32	U	U	10000			32	U	U	310			32	U	U	280		
Phenol	18000000	1800000	na	52	U	U	52	U	U	52	U	U	52	U	U	120			52	U	U	300	U	U	52	U	U	52	U	U	52	U	U	52	U	U
Pyrene	1700000	170000	na	83	U	U	83	U	U	83	U	U	83	U	U	83	U	U	83	U	U	800			83	U	U	83	U	U	83	U	U	83	U	U
Metals (mg/kg)																																				
Arsenic	1.6	0.39	15.8	NT			NT			NT			NT			NT			NT			NT			NT			3.66			2.5	U	U	3.81		
Barium	19000	1500	209	NT			NT			NT			NT			NT			NT			NT			NT			114			53.9			119		
Beryllium	200	16	1.02	NT			NT			NT			NT			NT			NT			NT			NT			0.427	U	U	0.624			0.74		
Chromium	150000	12000	65.3	NT			NT			NT			NT			NT			NT			NT			NT			14.4			30.3			15.9		
Lead	800	400	26.8	NT			NT			NT			NT			NT			NT			NT			NT			21.5			22			14.1		
Nickel	2000	150	62.8	NT			NT			NT			NT			NT			NT			NT			NT			6.04			10.3			5.77		
Selenium	510	39	na	NT			NT			NT			NT			NT			NT			NT			NT			0.668			0.449	U	U	0.449	U	U
Silver	510	39	na	NT			NT			NT			NT			NT			NT			NT			NT			0.0262			0.0124	U	U	0.0222		
Misc.																																				
Total Organic Carbon	na	na	na	NT			1000	U	U	NT			1000	U	U	NT			36100			NT			1000	U	U	NT			NT			NT		
Total Petroleum Hydrocarbons (mg/kg)	100	100	na	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	10	U	U	3570			10	U	U	12			335			10	U	U

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-5
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
TPH screening values are based on the VDEQ Storage Tank Program action levels
mg/kg = milligrams per kilogram (parts per million).
µg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
U = Analyte not detected.

Table 2-6
Analytes Detected in SWMU 48 and 49 Groundwater Samples - 1996 RFI

Analyte	Sample ID Sample Date		48MW1 1/20/95			48MW1 7/20/95			48MW2 1/19/95			48MW2 7/19/95			48MW3 1/20/95			48MW3 7/21/95			48MW4 7/27/95		
	MCL	**tw-RBC**	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q	Result	Lab Q	Val Q
VOCs (ug/L)																							
1,1,1-Trichloroethane	200	910	NT			4.1			NT			0.98			NT			1	U		1	U	
1,1-Dichloroethane	na	2.4	NT			2.3			NT			1	U		NT			1	U		1	U	
1,1-Dichloroethene	7	34	NT			1.1			NT			1	U		NT			1	U		1	U	
Carbon tetrachloride	5	0.44	NT			1	U		NT			92			NT			100			1	U	
Chloroform	80	0.19	NT			1	U		NT			6.7			NT			30			1	U	
Methylene chloride	5	4.8	NT			1	U		NT			1.1			NT			1	U		1	U	
Tetrachloroethene	5	0.11	NT			1.2			NT			1	U		NT			1	U		1	U	
Trichloroethene	5	2	NT			17			NT			11			NT			37			1	U	
SVOCs (ug/L)																							
bis(2-Ethylhexyl)phthalate	6	4.8	7.7	U		NT			12			NT			23			NT			NT		
Metals (ug/L), Total																							
Barium	2000	730	NT			81			NT			1070			NT			70.7			299		
Beryllium	4	7.3	NT			4.16			NT			10.7			NT			1.12	U		1.12	U	
Chromium	100	1600	NT			16.8	U		NT			42.8			NT			16.8	U		16.8	U	
Lead	15	na	NT			4.47	U	UJ	NT			9.29		J	NT			4.47	U		12.4		
Selenium	50	18	NT			2.72			NT			2.53	U		NT			2.53	U		2.53	U	
Metals (ug/L), Filtered																							
Barium	2000	730	67			69.7			215			816			91.9			69.8			295		
Beryllium	4	7.3	4.18			4.05			2.22			2.69			3.17			1.12	U		1.12	U	
Misc. (ug/L)																							
Chloride	250000	na	9300			NT			5480			NT			2990			NT			NT		
Hardness	na	na	445000			NT			268000			NT			368000			NT			NT		
Total Organic Carbon	na	na	1000	U		NT			2620			NT			1610			NT			NT		
Total Organic Halides	na	na	13.7			NT			33.6			NT			178			NT			NT		
Total Petroleum Hydrocarbons	na	1000	143			NT			480			NT			247			NT			NT		

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-6
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-SL exceedance.

tw-SLs for carcinogenic compounds are shown in red font.
tw-SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.
MCL Action Levels were used for copper and lead.
MCL Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA. August 2006.
tw-SL Source: ORNL Regional Screening Table. November 2011.
TPH screening value is based on the VDEQ Storage Tank Program action levels
µg/L = micrograms per liter (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
J = Estimated concentration.
UJ = Estimated concentration non-detect.

The draft RFI report was never finalized. Further RFI characterization of the site continued in 1998 as discussed in the next section.

2.6.4 RFI, ICF Kaiser, 1998

The objective of the 1998 RFI was to further refine the understanding of the nature and extent of contamination associated with previous disposal and/or burial practices. To meet these objectives, the following field tasks were performed for SWMUs 48 and 49:

- Excavation of a test pit at SWMU 48 to identify waste disposal boundaries.
- Collection of four subsurface soil samples from the floor of the test pit, analyzed for metals, VOCs, SVOCs, polynuclear aromatic hydrocarbons (PAHs), and explosives.
- Collection of 11 subsurface soil samples from three soil borings, analyzed for metals, VOCs, SVOCs, PAHs, and explosives.
- Collection of groundwater samples from the four monitoring wells installed during the 1996 RFI. Samples were analyzed for metals, VOCs, SVOCs, PAHs, explosives, total organic carbon (TOC), and total organic halides (TOX).

A summary of sampling for the 1998 RFI is included as **Table 2-1**. Analytes detected in soil samples are shown in **Table 2-7** (SWMU 48) and **Table 2-8** (SWMU 49) and in **Table 2-9** for groundwater. Detailed discussion of detections above SLs will be presented in *Section 4.0*. Sampling locations are depicted on **Figure 2-2**.

The analytical results confirmed the previous finding of explosives compounds [DNT mix; 1,3-dinitrobenzene (DNB); and 2,4,6-TNT] in the SWMU 48 disposal trenches and confirmed the VOC [CT and trichloroethene (TCE)] detections in groundwater. The draft RFI report was submitted in January 1999, but was never finalized. It recommended additional sampling to further define the nature and extent of contamination. Additional RFI characterization of the site continued in 2002 as presented in *Section 2.6.5*.

2.6.5 RFI, Shaw, 2002

Additional RFI characterization of these sites continued in 2002, with the collection of additional soil samples. **Table 2-1** presents the depths and analyses for the 2002 soil samples. Results from these soil samples are presented in **Table 2-10** (SWMU 48) and **Table 2-11** (SWMU 49).

The preliminary draft RFI utilized the combined data set from the 1992, 1996, 1998, and 2002 investigations to assess the two sites and perform an HHRA and a SLERA. At the time, RFAAP was considering a regional groundwater study, and the groundwater component of the HHRA was not included. Subsequently, a site-specific approach to groundwater investigations was adopted, and the preliminary draft RFI report was never submitted or finalized.

The soil results from this investigation are discussed in *Section 4.0* of this report, along with the other previous investigation data and data from the 2007 RFI.

2.6.6 Eastern HSA Groundwater Data Report, Shaw, 2006

Groundwater samples were collected from 13 wells located in the eastern end of the HSA as a data collection effort requested by USAEC to support the performance-based contract acquisition process. Four wells (48MW1, 48MW2, 48MW3, and 48MW4) from the combined study area were sampled for target compound list (TCL) VOCs, TCL SVOCs, PAHs, TCL pesticides/polychlorinated biphenyls (PCBs), explosives, TAL metals, and dioxins/furans. Wells 48MW1, 48MW2, and 48MW3 were regarded under SWMU 49, and well 48MW4 was regarded under SWMU 48. Results from the wells in the study area are shown in **Table 2-12** and are briefly discussed below. A more complete discussion of the data is included in *Section 4.0* of this report.

SVOCs, including PAHs, pesticides, PCBs, and explosives, were not detected in the wells. Ten VOCs were detected. CT and TCE each were detected above their maximum contaminant levels (MCLs) in two wells. CT was above its MCL [5 micrograms per liter (µg/L)] in SWMU 49 wells 48MW2 (29.2 µg/L) and 48MW3 (51.2 µg/L). TCE was detected greater than its MCL (5 µg/L) in SWMU 49 wells 48MW1 (5.5 µg/L) and 48MW3 (7.4 µg/L). These compounds were also detected during the 1998 RFI sampling. Concentrations have decreased from 180 µg/L (CT) and 37 µg/L (TCE) in 1998. As shown in **Table 2-12**, chloroform and tetrachloroethene (PCE) were detected above their tap water SLs (tw-SLs) in two and four wells, respectively. It should, however, be noted that the two chloroform detections were “B” flagged during data validation, indicating that chloroform was also detected in associated laboratory blanks. The “B” flags suggest that the chloroform is not site related. Three metals (aluminum, iron, and manganese) were above their secondary MCLs, and antimony, iron, and vanadium were found greater than their tw-SLs in one well each.

Table 2-7
Analytes Detected in SWMU 48 Soil Samples - 1998 RFI
Page 1 of 2

Analyte			Sample ID Sample Date Sample Depth	48SB6A 3/26/98 6-7					48SB6A2 4/8/98 6-7					48SB6B 3/26/98 14-16				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																		
1,2,4-Trichlorobenzene	99000	22000	na	8	U	R	8	8	990	U	U	990	990	7	U	UJ	7	7
Acetone	63000000	6100000	na	NT					1300	B	B	5	5	NT				
Benzene	5600	1100	na	17		J	5	5	990	U	U	990	990	7	U	U	7	7
Dichlorodifluoromethane	40000	9400	na	8	U	R	8	8	990	U	U	990	990	7	U	U	7	7
Ethylbenzene	27000	5400	na	8	U	R	8	8	990	U	U	990	990	7	U	U	7	7
m- & p-Xylene	na	na	na	8	U	R	8	8	1100			5	5	7	U	U	7	7
Methylene chloride	53000	11000	na	49		B	5	5	990	U	U	990	990	2	J	B	5	5
o-Xylene	1900000	380000	na	8	U	R	8	8	640	J	J	5	5	7	U	U	7	7
Toluene	4500000	500000	na	23		J	5	5	990	U	U	990	990	7	U	U	7	7
Trichlorofluoromethane	340000	79000	na	8	U	R	8	8	990	U	U	990	990	7	U	U	7	7
Vinyl chloride	1700	60	na	8	U	R	8	8	990	U	U	990	990	7	U	U	7	7
PAHs (ug/kg)																		
2-Methylnaphthalene	410000	31000	na	NT					NT					NT				
Anthracene	17000000	1700000	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Benz(a)anthracene	2100	150	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Benzo(a)pyrene	210	15	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Benzo(b)fluoranthene	2100	150	na	5.8	U	UL	5.8	5.8	NT					3.9	U	UL	3.9	3.9
Benzo(g,h,i)perylene	1700000	170000	na	5.8	U	UL	5.8	5.8	NT					3.9	U	UL	3.9	3.9
Benzo(k)fluoranthene	21000	1500	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Chrysene	210000	15000	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Dibenz(a,h)anthracene	210	15	na	5.8	U	UL	5.8	5.8	NT					3.9	U	UL	3.9	3.9
Fluoranthene	2200000	230000	na	48		L	5.8	5.8	NT					3.9	U	UL	3.9	3.9
Fluorene	2200000	230000	na	5.8	U	UL	5.8	5.8	NT					3.9	U	UL	3.9	3.9
Indeno(1,2,3-cd)pyrene	2100	150	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Naphthalene	18000	3600	na	29	U	UL	29	29	NT					20	U	UL	20	20
Phenanthrene	1700000	170000	na	2.9	U	UL	2.9	2.9	NT					2	U	UL	2	2
Pyrene	1700000	170000	na	25		J	2.9	2.9	NT					2	U	UL	2	2
SVOCs (ug/kg)																		
bis(2-Ethylhexyl)phthalate	120000	35000	na	130	J	J	520	520	NT					450	U	U	450	450
Di-n-butylphthalate	6200000	610000	na	360	J	J	520	520	NT					450	U	U	450	450
Fluoranthene	2200000	230000	na	NT					NT					NT				
N-nitrosodiphenylamine	350000	99000	na	650			520	520	NT					450	U	U	450	450
Phenanthrene	1700000	170000	na	NT					NT					NT				
Pyrene	1700000	170000	na	NT					NT					NT				
Pesticides (ug/kg)																		
4,4'-DDD	7200	2000	na	NT					NT					NT				
4,4'-DDE	5100	1400	na	NT					NT					NT				
4,4'-DDT	7000	1700	na	NT					NT					NT				
Endosulfan II	na	na	na	NT					NT					NT				
Endrin aldehyde	na	na	na	NT					NT					NT				
Methoxychlor	310000	31000	na	NT					NT					NT				
PCBs (mg/kg)																		
PCB-1254	0.74	0.022	na	NT					NT					NT				
Explosives (mg/kg)																		
1,3,5-Trinitrobenzene	2700	220	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
1,3-Dinitrobenzene	6.2	0.61	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
2,4,6-Trinitrotoluene	79	19	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
2,4-Dinitrotoluene	5.5	1.6	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
2,6-Dinitrotoluene	62	6.1	na	0.25	U	U	0.25	0.25	NT					0.24	U	U	0.24	0.24
4-amino-2,6-Dinitrotoluene	190	15	na	0.25	U	UL	0.25	0.25	NT					0.24	U	U	0.24	0.24
HMX	4900	380	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
Nitrobenzene	28	3.1	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
RDX	24	5.5	na	0.25	U	UL	0.25	0.25	NT					0.24	U	UL	0.24	0.24
Nitroglycerin	6.2	0.61	na	1.3	U	UL	1.3	1.3	NT					1.2	U	UL	1.2	1.2
Herbicides (ug/kg)	None detected																	
Metals (mg/kg)																		
Aluminum	99000	7700	40041	15700			0.95	0.95	NT					34200			0.81	0.81
Antimony	41	3.1	na	1.6	B	J	0.79	0.79	NT					1.1	B	J	0.67	0.67
Arsenic	1.6	0.39	15.8	2.8			0.95	0.95	NT					5.4			0.81	0.81
Barium	19000	1500	209	83.4		L	0.16	0.16	NT					72.9		L	0.13	0.13
Beryllium	200	16	1.02	0.16	U	U	0.16	0.16	NT					0.93		K	0.13	0.13
Calcium	na	na	na	35800			3.6	3.6	NT					860			3.1	3.1
Chromium	150000	12000	65.3	35.5			0.16	0.16	NT					42.2			0.13	0.13
Cobalt	30	2.3	72.3	7.6	B	L	0.16	0.16	NT					11.5		L	0.13	0.13
Copper	4100	310	53.5	33.3		K	0.16	0.16	NT					15.1		K	0.13	0.13
Iron	72000	5500	50962	18100			2.9	2.9	NT					39700			2.4	2.4
Lead	800	400	26.8	**59.6**			0.32	0.32	NT					8			0.27	0.27
Magnesium	na	na	na	4660			4.9	4.9	NT					1440			4.2	4.2
Manganese	2300	180	2543	148			0.16	0.16	NT					342			0.13	0.13
Mercury	4.3	1.0	0.13	0.16	U	U	0.16	0.16	NT					0.14	U	U	0.14	0.14
Nickel	2000	160	62.8	18.8		K	0.16	0.16	NT					17.6		K	0.13	0.13
Potassium	na	na	na	2200		K	7	7	NT					1430		K	5.9	5.9
Silver	510	39	na	0.16	U	U	0.32	0.32	NT					0.13	U	U	0.27	0.27
Sodium	na	na	na	537	B	K	4.8	4.8	NT					180	B	K	4	4
Thallium	10	0.78	2.11	0.79	U	UL	0.95	0.95	NT					0.67	U	UL	0.81	0.81
Vanadium	7.2	0.55	108	33		K	0.16	0.16	NT					41.2		K	0.13	0.13
Zinc	31000	2300	202	54.5		K	0.32	0.32	NT					46.6		K	0.27	0.27
Misc.																		
Total Organic Carbon (mg/kg)	na	na	na	NT					NT					NT				
pH	na	na	na	NT					NT					NT				

Analyte	48SB6B2 4/8/98 14-16					48SB6C 3/26/98 1-3					48SB6C2 4/8/98 1-3				
	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)															
1,2,4-Trichlorobenzene	850	U	U	850	850	60			5	5	1200	U	U	1200	1200
Acetone	1000	B	B	5	5	140		B	5	5	1400	B	B	5	5
Benzene	850	U	U	850	850	47	U	U	47	47	1200	U	U	1200	1200
Dichlorodifluoromethane	850	U	U	850	850	47	U	U	47	47	1200	U	U	1200	1200
Ethylbenzene	850	U	U	850	850	490		K	5	5	1200	U	U	1200	1200
m- & p-Xylene	850	U	U	850	850	47	U	U	47	47	1200	U	U	1200	1200
Methylene chloride	850	U	U	850	850	48		B	5	5	1200	U	U	1200	1200
o-Xylene	850	U	U	850	850	770		K	5	5	1200	U	U	1200	1200
Toluene	850	U	U	850	850	47	U	U	47	47	1200	U	U	1200	1200
Trichlorofluoromethane	850	U	U	850	850	47	U	U	47	47	1200	U	U	1200	1200
Vinyl chloride	850	U	U	850	850	47	U	U	47	47	1200	U	U	1200	1200
PAHs (ug/kg)															
2-Methylnaphthalene	NT					NT					NT				
Anthracene	NT					2	J	J	3.2	3.2	NT				
Benz(a)anthracene	NT					5.1			3.2	3.2	NT				
Benzo(a)pyrene	NT					5.6			3.2	3.2	NT				
Benzo(b)fluoranthene	NT					6.4	U	U	6.4	6.4	NT				
Benzo(g,h,i)perylene	NT					6.4	U	U	6.4	6.4	NT				
Benzo(k)fluoranthene	NT					5.4			3.2	3.2	NT				
Chrysene	NT					3.2	U	U	3.2	3.2	NT				
Dibenz(a,h)anthracene	NT					6.4	U	U	6.4	6.4	NT				
Fluoranthene	NT					8.2			6.4	6.4	NT				
Fluorene	NT					6.4	U	U	6.4	6.4	NT				
Indeno(1,2,3-cd)pyrene	NT					7			3.2	3.2	NT				
Naphthalene	NT					32	U	UL	32	32	NT				
Phenanthrene	NT					8.1			3.2	3.2	NT				
Pyrene	NT					4.6		J	3.2	3.2	NT				
SVOCs (ug/kg)															
bis(2-Ethylhexyl)phthalate	NT					350	J	J	620	620	NT				
Di-n-butylphthalate	NT					33000			6200	6200	NT				
Fluoranthene	NT					NT					NT				
N-nitrosodiphenylamine	NT					560	J	J	620	620	NT				
Phenanthrene	NT					NT					NT				
Pyrene	NT					NT					NT				
Pesticides (ug/kg)															
4,4'-DDD	NT					NT					NT				
4,4'-DDE	NT					NT					NT				
4,4'-DDT	NT					NT					NT				
Endosulfan II	NT					NT					NT				
Endrin aldehyde	NT					NT					NT				
Methoxychlor	NT					NT					NT				
PCBs (mg/kg)															
PCB-1254	NT					NT					NT				
Explosives (mg/kg)															
1,3,5-Trinitrobenzene	NT					0.25	U	UL	0.25	0.25	NT				
1,3-Dinitrobenzene	NT					0.25	U	UL	0.25	0.25	NT				
2,4,6-Trinitrotoluene	NT					0.25	U	UJ	0.25	0.25	NT				
2,4-Dinitrotoluene	NT					3.8		L	0.25	0.25	NT				
2,6-Dinitrotoluene	NT					1.1		J	0.25	0.25	NT				
4-amino-2,6-Dinitrotoluene	NT					0.25	U	UL	0.25	0.25	NT				
HMX	NT					0.25	U	UL	0.25	0.25	NT				
Nitrobenzene	NT					0.25	U	UL	0.25	0.25	NT				
RDX	NT					0.25	U	UL	0.25	0.25	NT				
Nitroglycerin	NT					1.3	U	UL	1.3	1.3	NT				
Herbicides (ug/kg)															
Metals (mg/kg)															
Aluminum	NT					11800			1.1	1.1	NT				
Antimony	NT					0.94	U	U	0.94	0.94	NT				
Arsenic	NT					5			1.1	1.1	NT				
Barium	NT					47		L	0.19	0.19	NT				
Beryllium	NT					0.56	B	B	0.19	0.19	NT				
Calcium	NT					120000			4.3	4.3	NT				
Chromium	NT					**65.4**			0.19	0.19	NT				
Cobalt	NT					4.2	B	L	0.19	0.19	NT				
Copper	NT					**149**		**K**	0.19	0.19	NT				
Iron	NT					11700			3.4	3.4	NT				
Lead	NT					**286**			0.38	0.38	NT				
Magnesium	NT					4730			5.8	5.8	NT				
Manganese	NT					123			0.19	0.19	NT				
Mercury	NT					0.18	U	U	0.18	0.18	NT				
Nickel	NT					39.2		K	0.19	0.19	NT				
Potassium	NT					805	B	K	8.3	8.3	NT				
Silver	NT					0.38	U	U	0.38	0.38	NT				
Sodium	NT					339	B	K	5.6	5.6	NT				
Thallium	NT					1.1	U	U	1.1	1.1	NT				
Vanadium	NT					16.2		K	0.19	0.19	NT				
Zinc	NT					73.6		K	0.38	0.38	NT				
Misc.															
Total Organic Carbon (mg/kg)	NT					NT					NT				
pH	NT					NT					NT				

Analyte	48SB7A 3/30/98 8-9					48SB7A2 4/9/98 8-9					48SB7B 3/30/98 10-11				
	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)															
1,2,4-Trichlorobenzene	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
Acetone	8		B	5	5	1100	B	B	5	5	8		B	5	5
Benzene	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
Dichlorodifluoromethane	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
Ethylbenzene	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
m- & p-Xylene	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
Methylene chloride	3	J	B	5	5	940	U	U	940	940	6		B	5	5
o-Xylene	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
Toluene	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
Trichlorofluoromethane	2	J	J	5	5	700	J	J	5	5	6	U	U	6	6
Vinyl chloride	8	U	U	8	8	940	U	U	940	940	6	U	U	6	6
PAHs (ug/kg)															
2-Methylnaphthalene	NT					NT					NT				
Anthracene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Benz(a)anthracene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Benzo(a)pyrene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Benzo(b)fluoranthene	42	U	U	42	42	NT					3.8	U	U	3.8	3.8
Benzo(g,h,i)perylene	42	U	U	42	42	NT					3.8	U	U	3.8	3.8
Benzo(k)fluoranthene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Chrysene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Dibenz(a,h)anthracene	42	U	U	42	42	NT					3.8	U	U	3.8	3.8
Fluoranthene	42	U	U	42	42	NT					3.8	U	U	3.8	3.8
Fluorene	42	U	U	42	42	NT					3.8	U	U	3.8	3.8
Indeno(1,2,3-cd)pyrene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Naphthalene	210	U	UL	210	210	NT					19	U	UL	19	19
Phenanthrene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
Pyrene	21	U	U	21	21	NT					1.9	U	U	1.9	1.9
SVOCs (ug/kg)															
bis(2-Ethylhexyl)phthalate	490	U	U	490	490	NT					380	U	U	380	380
Di-n-butylphthalate	490	U	UJ	490	490	NT					81	J	J	380	380
Fluoranthene	NT					NT					NT				
N-nitrosodiphenylamine	490	U	UJ	490	490	NT					380	U	U	380	380
Phenanthrene	NT					NT					NT				
Pyrene	NT					NT					NT				
Pesticides (ug/kg)															
4,4'-DDD	NT					NT					NT				
4,4'-DDE	NT					NT					NT				
4,4'-DDT	NT					NT					NT				
Endosulfan II	NT					NT					NT				
Endrin aldehyde	NT					NT					NT				
Methoxychlor	NT					NT					NT				
PCBs (mg/kg)															
PCB-1254	NT					NT					NT				
Explosives (mg/kg)															
1,3,5-Trinitrobenzene	102		L	25	25	NT					0.53		L	0.25	0.25
1,3-Dinitrobenzene	3.6		L	0.25	0.25	NT					0.25	U	UL	0.25	0.25
2,4,6-Trinitrotoluene	935		L	25	25	NT					35.68		L	1	1
2,4-Dinitrotoluene	0.25	U	UL	0.25	0.25	NT					0.25	U	UL	0.25	0.25
2,6-Dinitrotoluene	0.25	U	UL	0.25	0.25	NT					0.25	U	UL	0.25	0.25
4-amino-2,6-Dinitrotoluene	0.25	U	UL	0.25	0.25	NT					0.25	U	UL	0.25	0.25
HMX	0.25	U	UL	0.25	0.25	NT					0.25	U	UL	0.25	0.25
Nitrobenzene	0.25	U	UL	0.25	0.25	NT					0.25	U	UL	0.25	0.25
RDX	0.25	U	UL	0.25	0.25	NT					0.25	U	UL	0.25	0.25
Nitroglycerin	1.3	U	UL	1.3	1.3	NT					1.3	U	UL	1.3	1.3
Herbicides (ug/kg)															
Metals (mg/kg)															
Aluminum	24600			0.88	0.88	NT					16500			0.69	0.69
Antimony	0.9	B	J	0.73	0.73	NT					0.57	U	U	0.57	0.57
Arsenic	8			0.88	0.88	NT					3.5			0.69	0.69
Barium	111		L	0.15	0.15	NT					49.8		L	0.11	0.11
Beryllium	0.69	B	B	0.15	0.15	NT					0.76		B	0.11	0.11
Calcium	2640			3.4	3.4	NT					984			2.6	2.6
Chromium	33.3			0.15	0.15	NT					37.4			0.11	0.11
Cobalt	12.5		L	0.15	0.15	NT					15		L	0.11	0.11
Copper	36.9		K	0.15	0.15	NT					9.6		B	0.11	0.11
Iron	45600			2.6	2.6	NT					25300			2.1	2.1
Lead	25.6			0.29	0.29	NT					9			0.23	0.23
Magnesium	1810			4.5	4.5	NT					950			3.6	3.6
Manganese	176			0.15	0.15	NT					613			0.11	0.11
Mercury	0.15	U	U	0.15	0.15	NT					0.12	U	U	0.12	0.12
Nickel	24.4		K	0.15	0.15	NT					10.6		K	0.11	0.11
Potassium	2220		K	6.5	6.5	NT					909		K	5.1	5.1
Silver	0.39	B	J	0.29	0.29	NT					0.23	U	U	0.23	0.23
Sodium	211	B	B	4.4	4.4	NT					100	B	B	3.4	3.4
Thallium	0.88	U	U	0.88	0.88	NT					0.69	U	U	0.69	0.69
Vanadium	73.2		K	0.15	0.15	NT					23.1		K	0.11	0.11
Zinc	67.1		K	0.29	0.29	NT					29		K	0.23	0.23
Misc.															
Total Organic Carbon (mg/kg)	NT					NT					NT				
pH	NT					NT					NT				

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-7
Analytes Detected in SWMU 48 Soil Samples - 1998 RFI
Page 2 of 2

Analyte			Sample ID Sample Date Sample Depth	48TP1 3/24/98 6-6.5					48TP2 3/24/98 6-6.5					48TP2D 3/24/98 6-6.5					48TP3 3/24/98 6-6.5					48TP4 3/24/98 6-6.5				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																												
1,2,4-Trichlorobenzene	99000	22000	na	11	U	R	11	11	6	U	UJ	6	6	6	U	UJ	6	6	7	U	UJ	7	7	6	U	U	6	6
Acetone	63000000	6100000	na	NT					NT					NT					NT					NT				
Benzene	5600	1100	na	11	U	UJ	11	11	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
Dichlorodifluoromethane	40000	9400	na	6	J	J	5	5	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
Ethylbenzene	27000	5400	na	11	U	UJ	11	11	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
m- & p-Xylene	na	na	na	11	U	UJ	11	11	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
Methylene chloride	53000	11000	na	7	JB	B	5	5	2	J	B	5	5	3	B	B	5	5	2	J	B	5	5	2	J	B	5	5
o-Xylene	1900000	380000	na	11	U	UJ	11	11	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
Toluene	4500000	500000	na	11	U	UJ	11	11	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
Trichlorofluoromethane	340000	79000	na	7	J	J	5	5	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
Vinyl chloride	1700	60	na	11	J	J	11	11	6	U	U	6	6	6	U	U	6	6	7	U	UJ	7	7	6	U	U	6	6
PAHs (ug/kg)																												
2-Methylnaphthalene	410000	31000	na	NT					NT					NT					NT					NT				
Anthracene	17000000	1700000	na	3	U	U	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Benz(a)anthracene	2100	150	na	3	U	U	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Benzo(a)pyrene	210	15	na	3	U	U	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Benzo(b)fluoranthene	2100	150	na	6	U	U	6	6	4.2	U	U	4.2	4.2	4.2	U	U	4.2	4.2	4.4	U	U	4.4	4.4	4.2	U	U	4.2	4.2
Benzo(g,h,i)perylene	1700000	170000	na	6	U	U	6	6	4.2	U	U	4.2	4.2	4.2	U	U	4.2	4.2	4.4	U	U	4.4	4.4	4.2	U	U	4.2	4.2
Benzo(k)fluoranthene	21000	1500	na	3	U	U	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Chrysene	210000	15000	na	17		J	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Dibenz(a,h)anthracene	210	15	na	6	U	U	6	6	4.2	U	U	4.2	4.2	4.2	U	U	4.2	4.2	4.4	U	U	4.4	4.4	4.2	U	U	4.2	4.2
Fluoranthene	2200000	230000	na	6	U	U	6	6	4.2	U	U	4.2	4.2	4.2	U	U	4.2	4.2	4.4	U	U	4.4	4.4	4.2	U	U	4.2	4.2
Fluorene	2200000	230000	na	6	U	U	6	6	4.2	U	U	4.2	4.2	4.2	U	U	4.2	4.2	4.4	U	U	4.4	4.4	4.2	U	U	4.2	4.2
Indeno(1,2,3-cd)pyrene	2100	150	na	3	U	U	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Naphthalene	18000	3600	na	30	U	U	30	30	21	U	U	21	21	21	U	U	21	21	22	U	U	22	22	21	U	U	21	21
Phenanthrene	1700000	170000	na	94		J	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
Pyrene	1700000	170000	na	3	U	U	3	3	2.1	U	U	2.1	2.1	2.1	U	U	2.1	2.1	2.2	U	U	2.2	2.2	2.1	U	U	2.1	2.1
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	720	U	U	720	720	430	U	U	430	430	430	U	U	430	430	440	U	U	440	440	430	U	U	430	430
Di-n-butylphthalate	6200000	610000	na	720	U	U	720	720	430	U	U	430	430	430	U	U	430	430	440	U	U	440	440	430	U	U	430	430
Fluoranthene	2200000	230000	na	NT					NT					NT					NT					NT				
N-nitrosodiphenylamine	350000	99000	na	720	U	U	720	720	430	U	U	430	430	430	U	U	430	430	440	U	U	440	440	430	U	U	430	430
Phenanthrene	1700000	170000	na	NT					NT					NT					NT					NT				
Pyrene	1700000	170000	na	NT					NT					NT					NT					NT				
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	NT					NT					NT					NT					NT				
4,4'-DDE	5100	1400	na	NT					NT					NT					NT					NT				
4,4'-DDT	7000	1700	na	NT					NT					NT					NT					NT				
Endosulfan II	na	na	na	NT					NT					NT					NT					NT				
Endrin aldehyde	na	na	na	NT					NT					NT					NT					NT				
Methoxychlor	310000	31000	na	NT					NT					NT					NT					NT				
PCBs (mg/kg)																												
PCB-1254	0.74	0.022	na	NT					NT					NT					NT					NT				
Explosives (mg/kg)																												
1,3,5-Trinitrobenzene	2700	220	na	1.4		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
1,3-Dinitrobenzene	6.2	0.61	na	2.7		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
2,4,6-Trinitrotoluene	79	19	na	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
2,4-Dinitrotoluene	5.5	1.6	na	6.7		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
2,6-Dinitrotoluene	62	6.1	na	1.3			0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
4-amino-2,6-Dinitrotoluene	190	15	na	5.5		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
HMX	4900	380	na	5.2		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
Nitrobenzene	28	3.1	na	1		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
RDX	24	5.5	na	0.85		J	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25	0.25	U	U	0.25	0.25
Nitroglycerin	6.2	0.61	na	1.3	U	U	1.3	1.3	1.3	U	U	1.3	1.3	1.3	U	U	1.3	1.3	1.3	U	U	1.3	1.3	1.3	U	U	1.3	1.3
Herbicides (ug/kg)	None detected																											
Metals (mg/kg)																												
Aluminum	99000	7700	40041	9230			1.3	1.3	**47400**			0.75	0.75	**51500**			0.78	0.78	**50700**			0.79	0.79	**47900**			0.78	0.78
Antimony	41	3.1	na	0.66	U	U	1.1	1.1	1.3	B	J	0.62	0.62	2.5	B	J	0.65	0.65	1.5	B	J	0.66	0.66	1.5	B	J	0.65	0.65
Arsenic	1.6	0.39	15.8	8.1			1.3	1.3	4.3			0.75	0.75	6			0.78	0.78	4.8			0.79	0.79	4.8			0.78	0.78
Barium	19000	1500	209	34.6	B	L	0.22	0.22	71.8		L	0.12	0.12	79.9		L	0.13	0.13	70.6		L	0.13	0.13	80.4		L	0.13	0.13
Beryllium	200	16	1.02	**1.5**		**K**	0.22	0.22	0.48	B	K	0.12	0.12	0.53	B	K	0.13	0.13	0.51	B	K	0.13	0.13	0.55	B	K	0.13	0.13
Calcium	na	na	na	4650			5	5	697			2.9	2.9	799			3	3	266	B	J	3	3	246	B	J	3	3
Chromium	150000	12000	65.3	23.2			0.22	0.22	28.4			0.12	0.12	34.2			0.13	0.13	33			0.13	0.13	31.2			0.13	0.13
Cobalt	30	2.3	72.3	13.8		L	0.22	0.22	6.7		L	0.12	0.12	7.5		L	0.13	0.13	7.5		L	0.13	0.13	6.2	B	L	0.13	0.13
Copper	4100	310	53.5	15.4		K	0.22	0.22	18.6		K	0.12	0.12	21.1		K	0.13	0.13	19.7		K	0.13	0.13	20.1		K	0.13	0.13
Iron	72000	5500	50962	16700			3.9	3.9	**51100**			2.2	2.2	**57200**			2.3	2.3	**55000**			2.4	2.4	**54800**			2.3	2.3
Lead	800	400	26.8	17.8			0.44	0.44	17			0.25	0.25	18.1			0.26	0.26	14.7			0.26	0.26	15.8			0.26	0.26
Magnesium	na	na	na	442	B	J	6.8	6.8	2310			3.9	3.9	2520			4	4	1980			4.1	4.1	2160			4	4
Manganese	2300	180	2543	314			0.22	0.22	188			0.12	0.12	197			0.13	0.13	218			0.13	0.13	163			0.13	0.13
Mercury	4.3	1.0	0.13	0.22	U	U	0.22	0.22	0.13	U	U	0.13	0.13	0.13	U	U	0.13	0.13	0.13	U	U	0.13	0.13	0.13	U	U	0.13	0.13
Nickel	2000	160	62.8	8.6	B	K	0.22	0.22	20.9		K	0.12	0.12	22.6		K	0.13	0.13	21.2		K	0.13	0.13	22		K	0.13	0.13
Potassium	na	na	na	176	B	K	9.6	9.6	2910		K	5.5	5.5	3180		K	5.7	5.7	2670		K	5.8	5.8	2920		K	5.7	5.7
Silver	510	39	na	0.22	U	U	0.44	0.44	0.12	U	U	0.25	0.25	0.13	U	U	0.26	0.26	0.13	U	U	0.26	0.26	0.13	U	U	0.26	0.26
Sodium	na	na	na	5740		K	6.6	6.6	323	B	K	3.7	3.7	671		K	3.9	3.9	288	B	K	4	4	224	B	K	3.9	3.9
Thallium	10	0.78	2.11	1.1	U	UL	1.3	1.3	1.9		L	0.75	0.75	**2.4**		**L**	0.78	0.78	0.66	U	UL	0.79	0.79	0.65	U	UL	0.78	0.78
Vanadium	7.2	0.55	108	12.1		K	0.22	0.22	94.6		K	0.12	0.12	105		K	0.13	0.13	100		K	0.13	0.13	96.4		K	0.13	0.13
Zinc	31000	2300	202	58.7		K	0.44	0.44	65.6		K	0.25	0.25	72.3		K	0.26	0.26	70.2		K	0.26	0.26	67.8		K	0.26	0.26
Misc.																												
Total Organic Carbon (mg/kg)	na	na	na	NT					NT					NT					NT					NT				
pH	na	na	na	NT					NT					NT					NT					NT				

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-7
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
B (organics) = Blank contamination. Value detected in sample and associated blank.
B (metals) = Value <MRL and >MDL and is considered estimated.
J (organics) = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
R = Unreliable rejected result.
U = Analyte not detected.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 2-8
Analytes Detected in SWMU 49 Soil Samples - 1998 RFI

Analyte	Sample ID Sample Date Sample Depth			49SB1A 3/31/98 8-10					49SB1B 3/31/98 18-24					49SB1B2 4/9/98 18-24				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																		
2-Butanone	20000000	2800000	na	13		J	5	5	11		J	5	5	780	U	U	780	780
Acetone	63000000	6100000	na	97		B	5	5	65		B	5	5	780	U	U	780	780
Ethylbenzene	27000	5400	na	28		J	5	5	360		L	5	5	1700			5	5
m- & p-Xylene	na	na	na	72		J	5	5	6	U	U	6	6	5300			5	5
Methylene chloride	53000	11000	na	4	J	B	5	5	9		B	5	5	780	U	U	780	780
o-Xylene	300000	69000	na	86		J	5	5	200			5	5	710	J	J	5	5
PAHs (ug/kg)																		
Benzo(a)pyrene	210	15	na	40	U	U	40	40	42	U	U	42	42	NT				
Fluorene	2200000	230000	na	1600			80	80	1800			83	83	NT				
Naphthalene	18000	3600	na	920		L	400	400	2500		L	420	420	NT				
Phenanthrene	1700000	170000	na	40	U	U	40	40	42	U	U	42	42	NT				
SVOCs (ug/kg)																		
2-Methylnaphthalene	410000	31000	na	16000			2000	2000	15000			2100	2100	NT				
bis(2-Ethylhexyl)phthalate	120000	35000	na	2000	U	UJ	2000	2000	410	U	UJ	410	410	NT				
Dibenzofuran	100000	7800	na	2000	U	U	2000	2000	1800			410	410	NT				
Explosives (mg/kg)																		
2,4,6-Trinitrotoluene	79	19	na	0.4		L	0.24	0.24	0.25	U	UL	0.25	0.25	NT				
2-amino-4,6-Dinitrotoluene	200	15	na	0.6		L	0.24	0.24	0.25	U	UL	0.25	0.25	NT				
Tetryl	250	24	na	0.72		L	0.24	0.24	0.6		L	0.25	0.25	NT				
Metals (mg/kg)																		
Aluminum	99000	7700	40041	27300			0.72	0.72	18300			0.74	0.74	NT				
Antimony	41	3.1	na	0.6	U	U	0.6	0.6	0.62	U	U	0.62	0.62	NT				
Arsenic	1.6	0.39	15.8	3.2			0.72	0.72	2.5			0.74	0.74	NT				
Barium	19000	1500	209	56.7		L	0.12	0.12	35		L	0.12	0.12	NT				
Beryllium	200	16	1.02	0.6	B	B	0.12	0.12	**1.7**		**J**	0.12	0.12	NT				
Calcium	na	na	na	714			2.7	2.7	304	B	J	2.8	2.8	NT				
Chromium	150000	12000	65.3	29.2			0.12	0.12	22.3			0.12	0.12	NT				
Cobalt	30	2.3	72.3	3.9	B	L	0.12	0.12	28.7		L	0.12	0.12	NT				
Copper	4100	310	53.5	24		K	0.12	0.12	5.1		B	0.12	0.12	NT				
Iron	72000	5500	50962	33600			2.2	2.2	40300			2.2	2.2	NT				
Lead	800	400	26.8	**55.6**			0.24	0.24	9.6			0.25	0.25	NT				
Magnesium	na	na	na	1110			3.7	3.7	2270			3.8	3.8	NT				
Manganese	2300	180	2543	74.5			0.12	0.12	350			0.12	0.12	NT				
Nickel	2000	150	62.8	11.7		K	0.12	0.12	22.5		K	0.12	0.12	NT				
Potassium	na	na	na	1280		K	5.3	5.3	1780		K	5.4	5.4	NT				
Sodium	na	na	na	149	B	B	3.6	3.6	3.7	U	U	3.7	3.7	NT				
Thallium	1	0.78	2.11	0.78	B	J	0.72	0.72	0.74	U	U	0.74	0.74	NT				
Vanadium	520	39	108	63.2		K	0.12	0.12	23.2		K	0.12	0.12	NT				
Zinc	31000	2300	202	48.4		K	0.24	0.24	23.6		K	0.25	0.25	NT				

Analyte	49SB1C 3/31/98 28-32					49SB1C2 4/9/98 28-32					49SB1D 3/31/98 38-40				
	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)															
2-Butanone	6	J	J	5	5	770	U	U	770	770	6	U	U	6	6
Acetone	58		B	5	5	830	B	B	5	5	7		B	5	5
Ethylbenzene	190	E	L	5	5	1100			5	5	6	U	U	6	6
m- & p-Xylene	6	U	UL	6	6	1700			5	5	6	U	U	6	6
Methylene chloride	3	J	B	5	5	770	U	U	770	770	3	J	B	5	5
o-Xylene	6	U	UL	6	6	770	U	U	770	770	6	U	U	6	6
PAHs (ug/kg)															
Benzo(a)pyrene	21	U	U	21	21	NT					2	U	U	2	2
Fluorene	680			41	41	NT					11			3.9	3.9
Naphthalene	1500		L	210	210	NT					20	U	UL	20	20
Phenanthrene	21	U	U	21	21	NT					2	U	U	2	2
SVOCs (ug/kg)															
2-Methylnaphthalene	11000			2000	2000	NT					390	U	U	390	390
bis(2-Ethylhexyl)phthalate	410	U	U	410	410	NT					390	U	U	390	390
Dibenzofuran	410	U	U	410	410	NT					390	U	U	390	390
Explosives (mg/kg)															
2,4,6-Trinitrotoluene	0.24	U	UL	0.24	0.24	NT					0.24	U	UL	0.24	0.24
2-amino-4,6-Dinitrotoluene	0.24	U	UL	0.24	0.24	NT					0.24	U	UL	0.24	0.24
Tetryl	0.24	U	UL	0.24	0.24	NT					0.24	U	UL	0.24	0.24
Metals (mg/kg)															
Aluminum	22700			0.72	0.72	NT					19900			0.69	0.69
Antimony	0.87	B	J	0.6	0.6	NT					0.75	B	J	0.58	0.58
Arsenic	3.8			0.72	0.72	NT					3.9			0.69	0.69
Barium	53.4		L	0.12	0.12	NT					54.6		L	0.12	0.12
Beryllium	**3**		**J**	0.12	0.12	NT					**1.6**		**J**	0.12	0.12
Calcium	771			2.8	2.8	NT					592			2.7	2.7
Chromium	27.5			0.12	0.12	NT					35.3			0.12	0.12
Cobalt	27.1		L	0.12	0.12	NT					22.3		L	0.12	0.12
Copper	7.6		J	0.12	0.12	NT					14.5		K	0.12	0.12
Iron	43000			2.2	2.2	NT					39000			2.1	2.1
Lead	5.5			0.24	0.24	NT					6.9			0.23	0.23
Magnesium	9610			3.7	3.7	NT					8640			3.6	3.6
Manganese	449			0.12	0.12	NT					271			0.12	0.12
Nickel	48.2		K	0.12	0.12	NT					54.1		K	0.12	0.12
Potassium	2900		K	5.3	5.3	NT					1950		K	5.1	5.1
Sodium	188	B	B	3.6	3.6	NT					122	B	B	3.5	3.5
Thallium	0.72	U	U	0.72	0.72	NT					0.69	U	U	0.69	0.69
Vanadium	21		K	0.12	0.12	NT					18.8		K	0.12	0.12
Zinc	28.7		K	0.24	0.24	NT					15.8		K	0.23	0.23

Analyte	49SB1D2 4/9/98 38-40					49SB1E 3/31/98 48-50					49SB1F 3/31/98 58-60				
	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)															
2-Butanone	740	U	U	740	740	6	U	U	6	6	6	U	U	6	6
Acetone	1100	B	B	5	5	6		B	5	5	9		B	5	5
Ethylbenzene	740	U	U	740	740	6	U	U	6	6	6	U	U	6	6
m- & p-Xylene	740	U	U	740	740	6	U	U	6	6	6	U	U	6	6
Methylene chloride	740	U	U	740	740	2	J	B	5	5	5	J	B	5	5
o-Xylene	740	U	U	740	740	6	U	U	6	6	6	U	U	6	6
PAHs (ug/kg)															
Benzo(a)pyrene	NT					2	U	U	2	2	0.66	J	J	2	2
Fluorene	NT					3.9	U	U	3.9	3.9	3.9	U	U	3.9	3.9
Naphthalene	NT					20	U	UL	20	20	20	U	UL	20	20
Phenanthrene	NT					2.9			2	2	1.8	J	J	2	2
SVOCs (ug/kg)															
2-Methylnaphthalene	NT					400	U	U	400	400	400	U	U	400	400
bis(2-Ethylhexyl)phthalate	NT					64	J	J	400	400	400	U	U	400	400
Dibenzofuran	NT					400	U	U	400	400	400	U	U	400	400
Explosives (mg/kg)															
2,4,6-Trinitrotoluene	NT					0.24	U	UL	0.24	0.24	0.25	U	UL	0.25	0.25
2-amino-4,6-Dinitrotoluene	NT					0.24	U	UL	0.24	0.24	0.25	U	UL	0.25	0.25
Tetryl	NT					0.24	U	UL	0.24	0.24	0.25	U	UL	0.25	0.25
Metals (mg/kg)															
Aluminum	NT					14800			0.71	0.71	13000			0.7	0.7
Antimony	NT					0.85	B	J	0.59	0.59	0.68	B	J	0.58	0.58
Arsenic	NT					4.2			0.71	0.71	2.8			0.7	0.7
Barium	NT					63.4		L	0.12	0.12	82		L	0.12	0.12
Beryllium	NT					**1.1**		**J**	0.12	0.12	0.84		J	0.12	0.12
Calcium	NT					1780			2.7	2.7	1710			2.7	2.7
Chromium	NT					27.3			0.12	0.12	25.4			0.12	0.12
Cobalt	NT					12.3		L	0.12	0.12	29		L	0.12	0.12
Copper	NT					12.6		B	0.12	0.12	37.5		K	0.12	0.12
Iron	NT					37700			2.1	2.1	33700			2.1	2.1
Lead	NT					3			0.24	0.24	4.5			0.23	0.23
Magnesium	NT					10300			3.7	3.7	9820			3.6	3.6
Manganese	NT					532			0.12	0.12	421			0.12	0.12
Nickel	NT					42.7		K	0.12	0.12	45.1		K	0.12	0.12
Potassium	NT					1000		K	5.2	5.2	1360		K	5.1	5.1
Sodium	NT					113	B	B	3.6	3.6	116	B	B	3.5	3.5
Thallium	NT					0.93	B	J	0.71	0.71	0.7	U	U	0.7	0.7
Vanadium	NT					22.3		K	0.12	0.12	14.3		K	0.12	0.12
Zinc	NT					17.2		K	0.24	0.24	13.3		K	0.23	0.23

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-8
Legend

<u>12</u>	**<u>J</u>**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
B (organics) = Blank contamination. Value detected in sample and associated blank.
B (metals) = Value <MRL and >MDL and is considered estimated.
E (organics) = Value exceeded upper calibration level. Value is considered estimated.
J (organics) = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
U = Analyte not detected.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 2-9

Analytes Detected in SWMU 48 and 49 Groundwater Samples - 1998 RFI

Analyte	Sample ID		48MW1-2					48MW1-2, Filtered					48MW1-2D				
	Sample Date		4/8/98					4/8/98					4/8/98				
	MCL	**tw-SL**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																	
1,2-Dichloroethane	5	0.15	5	U	U	*5*	*5*	NT					5	U	U	*5*	*5*
Acetone	na	1200	3	B	B	*5*	*3*	NT					4	B	B	*5*	*4*
Carbon tetrachloride	5	0.39	5	U	U	*5*	*5*	NT					5	U	U	*5*	*5*
Chloroform	80	0.19	5	U	U	*5*	*5*	NT					5	U	U	*5*	*5*
Methylene chloride	5	4.7	5	U	U	*5*	*5*	NT					5	U	U	*5*	*5*
Trichloroethene	5	0.44	8		J	*5*	*8*	NT					8		J	*5*	*8*
Trichlorofluoromethane	na	110	5	U	U	*5*	*5*	NT					5	U	U	*5*	*5*
PAHs (ug/L)	None detected																
SVOCs (ug/L)																	
Di-n-butylphthalate	na	67	10	U	U	*10*	*10*	NT					10	U	U	*10*	*10*
Explosives (ug/L)	None detected																
Metals (ug/L)																	
Aluminum	50	16000	190	B	J	*6*	*190*	28.6	B	B	*6*	*28.6*	164	B	J	*6*	*164*
Arsenic	10	0.045	6	U	U	*6*	*6*	6	U	UL	*6*	*6*	6	U	U	*6*	*6*
Barium	2000	290	93.6	B	J	*1*	*93.6*	81.7	B	J	*1*	*81.7*	100	B	J	*1*	*100*
Beryllium	4	1.6	1.2	B	B	*1*	*1.2*	1	U	U	*1*	*1*	1	U	U	*1*	*1*
Calcium	na	na	69800			*23*	*69800*	67800			*23*	*67800*	59700			*23*	*59700*
Chromium	100	1600	13.9			*1*	*13.9*	1	B	J	*1*	*1*	12.3			*1*	*12.3*
Cobalt	na	0.47	1	U	UJ	*1*	*1*	2.9	B	L	*1*	*2.9*	1	U	UL	*1*	*1*
Copper	1300	62	5	B	B	*1*	*5*	14.7	B	B	*1*	*14.7*	4.9	B	B	*1*	*4.9*
Iron	300	1100	324			*18*	*324*	23.8	B	B	*18*	*23.8*	265			*18*	*265*
Lead	15	na	2	U	UL	*2*	*2*	2	U	U	*2*	*2*	2	U	UL	*2*	*2*
Magnesium	na	na	34700			*31*	*34700*	33000			*31*	*33000*	34000			*31*	*34000*
Manganese	50	32	8.3	B	J	*1*	*8.3*	11.6	B	J	*1*	*11.6*	8.2	B	J	*1*	*8.2*
Nickel	na	30	8.9	B	K	*1*	*8.9*	7.2	B	K	*1*	*7.2*	8	B	K	*1*	*8*
Potassium	na	na	2340	B	K	*44*	*2340*	2230	B	J	*44*	*2230*	2470	B	K	*44*	*2470*
Selenium	50	7.8	4	U	U	*4*	*4*	4	U	UL	*4*	*4*	4	U	U	*4*	*4*
Sodium	na	na	23600	J	K	*30*	*23600*	23000		K	*30*	*23000*	22800	J	K	*30*	*22800*
Thallium	2	0.016	6	U	U	*6*	*6*	6	U	U	*6*	*6*	6	B	J	*6*	*6*
Vanadium	na	7.8	1.3	B	B	*1*	*1.3*	1	U	U	*1*	*1*	1.6	B	B	*1*	*1.6*
Zinc	5000	470	16.9	B	B	*2*	*16.9*	12.5	B	B	*2*	*12.5*	12.7	B	B	*2*	*12.7*
Misc. (ug/L)																	
Total Organic Carbon	na	na	100000			*100000*	*100000*	NT					100000			*100000*	*100000*
Total Organic Halides	na	na	50	U	U	*50*	*50*	NT					50	U	U	*50*	*50*

Analyte	48MW1-2D, Filtered					48MW2-2					48MW2-2, Filtered					48MW3-2				
	4/8/98					4/2/98					4/2/98					4/2/98				
	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																				
1,2-Dichloroethane	NT					5	U	U	*5*	*5*	NT					4	J	J	*5*	*4*
Acetone	NT					5	U	U	*5*	*5*	NT					5	B	B	*5*	*5*
Carbon tetrachloride	NT					140			*5*	*140*	NT					180			*5*	*180*
Chloroform	NT					9		B	*5*	*9*	NT					27		B	*5*	*27*
Methylene chloride	NT					2	J	B	*5*	*2*	NT					5	J	B	*5*	*5*
Trichloroethene	NT					18		J	*5*	*18*	NT					33		J	*5*	*33*
Trichlorofluoromethane	NT					5	U	U	*5*	*5*	NT					5	U	U	*5*	*5*
PAHs (ug/L)																				
SVOCs (ug/L)																				
Di-n-butylphthalate	NT					10	U	U	*10*	*10*	NT					10	U	U	*10*	*10*
Explosives (ug/L)																				
Metals (ug/L)																				
Aluminum	10.7	B	B	*6*	*10.7*	19800			*6*	*19800*	9.6	B	B	*6*	*9.6*	6	U	U	*6*	*6*
Arsenic	6	U	UL	*6*	*6*	9.9	B	K	*6*	*9.9*	6	U	U	*6*	*6*	6	U	U	*6*	*6*
Barium	78.2	B	L	*1*	*78.2*	882		J	*1*	*882*	428		L	*1*	*428*	57.6	B	J	*1*	*57.6*
Beryllium	1	U	U	*1*	*1*	2	B	B	*1*	*2*	1	U	U	*1*	*1*	1.2	B	B	*1*	*1.2*
Calcium	57100			*23*	*57100*	310000			*23*	*310000*	52300			*23*	*52300*	97200			*23*	*97200*
Chromium	1	U	U	*1*	*1*	44			*1*	*44*	4.1	B	J	*1*	*4.1*	1	U	U	*1*	*1*
Cobalt	2.4	B	L	*1*	*2.4*	19.1	B	J	*1*	*19.1*	3.6	B	L	*1*	*3.6*	2.4	B	J	*1*	*2.4*
Copper	16.7	B	B	*1*	*16.7*	55.2	J	J	*1*	*55.2*	14.6	B	B	*1*	*14.6*	8	B	K	*1*	*8*
Iron	18	U	U	*18*	*18*	29300			*18*	*29300*	18	U	U	*18*	*18*	18	U	U	*18*	*18*
Lead	2	U	U	*2*	*2*	10.8			*2*	*10.8*	2	U	UJ	*2*	*2*	2	U	UL	*2*	*2*
Magnesium	28400			*31*	*28400*	151000			*31*	*151000*	22700			*31*	*22700*	40400			*31*	*40400*
Manganese	9.8	B	J	*1*	*9.8*	462			*1*	*462*	10.3	B	J	*1*	*10.3*	8.6	B	J	*1*	*8.6*
Nickel	6.5	B	K	*1*	*6.5*	35.9	B	K	*1*	*35.9*	1.3	B	K	*1*	*1.3*	1	U	U	*1*	*1*
Potassium	1920	B	K	*44*	*1920*	8010		K	*44*	*8010*	1200	B	K	*44*	*1200*	1200	B	K	*44*	*1200*
Selenium	4	U	UL	*4*	*4*	4	U	U	*4*	*4*	4	U	U	*4*	*4*	4	U	U	*4*	*4*
Sodium	20300		K	*30*	*20300*	3570	B	J	*30*	*3570*	2050	J	K	*30*	*2050*	1640	B	K	*30*	*1640*
Thallium	6	U	U	*6*	*6*	6	U	U	*6*	*6*	6	U	U	*6*	*6*	6	U	U	*6*	*6*
Vanadium	1	U	U	*1*	*1*	55.6		K	*1*	*55.6*	1.8	B	B	*1*	*1.8*	1.5	B	B	*1*	*1.5*
Zinc	8.8	B	B	*2*	*8.8*	59.9		J	*2*	*59.9*	2	U	U	*2*	*2*	9	B	B	*2*	*9*
Misc. (ug/L)																				
Total Organic Carbon	NT					100000			*100000*	*100000*	NT					100000			*100000*	*100000*
Total Organic Halides	NT					90			*50*	*90*	NT					110			*50*	*110*

Analyte	48MW3-2, Filtered					48MW4-2					48MW4-2, Filtered				
	4/2/98					4/8/98					4/6/98				
	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)															
1,2-Dichloroethane	NT					5	U	U	*5*	*5*	NT				
Acetone	NT					4	B	B	*5*	*4*	NT				
Carbon tetrachloride	NT					5	U	U	*5*	*5*	NT				
Chloroform	NT					5	U	U	*5*	*5*	NT				
Methylene chloride	NT					5	U	U	*5*	*5*	NT				
Trichloroethene	NT					5	U	U	*5*	*5*	NT				
Trichlorofluoromethane	NT					5	J	J	*5*	*5*	NT				
PAHs (ug/L)															
SVOCs (ug/L)															
Di-n-butylphthalate	NT					2	J	J	*10*	*2*	NT				
Explosives (ug/L)															
Metals (ug/L)															
Aluminum	278			*6*	*278*	248			*6*	*248*	27.5	B	B	*6*	*27.5*
Arsenic	6	U	U	*6*	*6*	6	U	UJ	*6*	*6*	6	U	UL	*6*	*6*
Barium	66.1	B	J	*1*	*66.1*	215		J	*1*	*215*	180	B	L	*1*	*180*
Beryllium	1	B	B	*1*	*1*	1.3	B	B	*1*	*1.3*	1	U	U	*1*	*1*
Calcium	120000			*23*	*120000*	54000			*23*	*54000*	51500			*23*	*51500*
Chromium	1.3	B	J	*1*	*1.3*	6.3	B	J	*1*	*6.3*	9.3	B	J	*1*	*9.3*
Cobalt	1	U	UJ	*1*	*1*	1.1	B	J	*1*	*1.1*	3.2	B	L	*1*	*3.2*
Copper	38.3		K	*1*	*38.3*	10.1	B	B	*1*	*10.1*	15.9	B	B	*1*	*15.9*
Iron	578			*18*	*578*	405			*18*	*405*	18	U	U	*18*	*18*
Lead	2.3	B	L	*2*	*2.3*	2	U	UL	*2*	*2*	2	U	U	*2*	*2*
Magnesium	58100			*31*	*58100*	46300			*31*	*46300*	44800			*31*	*44800*
Manganese	25.6		J	*1*	*25.6*	5.3	B	J	*1*	*5.3*	9.2			*1*	*9.2*
Nickel	1	U	U	*1*	*1*	3.9	B	K	*1*	*3.9*	7.3	B	K	*1*	*7.3*
Potassium	1650	B	K	*44*	*1650*	1940	B	K	*44*	*1940*	1790	B	K	*44*	*1790*
Selenium	4.6	B	J	*4*	*4.6*	4	U	U	*4*	*4*	4	U	UL	*4*	*4*
Sodium	2330	J	K	*30*	*2330*	9430		K	*30*	*9430*	9040		K	*30*	*9040*
Thallium	6	U	U	*6*	*6*	6	U	U	*6*	*6*	6	U	U	*6*	*6*
Vanadium	2.9	B	B	*1*	*2.9*	1.3	B	B	*1*	*1.3*	1	U	U	*1*	*1*
Zinc	11.6	B	B	*2*	*11.6*	18.5	B	B	*2*	*18.5*	13.9	B	B	*2*	*13.9*
Misc. (ug/L)															
Total Organic Carbon	NT					100000			*100000*	*100000*	NT				
Total Organic Halides	NT					50	U	U	*50*	*50*	NT				

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-9
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-SL exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-SLs for carcinogenic compounds are shown in red font.
tw-SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.
MCL Action Levels were used for copper and lead.
MCL Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA. August 2006.
tw-SL Source: ORNL Regional Screening Table. November 2011.
µg/L = micrograms per liter (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
B (organics) = Blank contamination. Value detected in sample and associated blank.
B (metals) = Value <MRL and >MDL and is considered estimated.
J (organics) = Value <MRL and >MDL and is considered estimated.
J (metals) = Estimated result.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
U = Analyte not detected.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 2-10
Analytes Detected in SWMU 48 Soil Samples - 2002 RFI
Page 1 of 2

Analyte			Sample ID Sample Date Sample Depth	48SB08A 6/24/02 0-0.5					48SB08B 6/24/02 4-6					48SB08C 6/24/02 8-10					48SB09A 6/24/02 0-0.5					48SB09B 6/24/02 4-6				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	10	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																												
Acetone	63000000	6100000	na	26		B	2.2	26	5.6	U	UJ	2.5	5.6	5.4	U	UJ	2.4	5.4	NT					NT				
Toluene	4500000	500000	na	0.84	J	B	0.32	0.84	5.6	U	U	0.36	5.6	5.4	U	U	0.35	5.4	NT					NT				
PAHs (ug/kg)																												
2-Methylnaphthalene	410000	31000	na	2.5		B	0.63	2.5	1.2	J	B	0.71	1.2	0.89	J	B	0.69	0.89	NT					NT				
Anthracene	17000000	1700000	na	1.9	U	U	0.2	1.9	2.1	U	U	0.23	2.1	2.1	U	U	0.23	2.1	NT					NT				
Benz(a)anthracene	2100	150	na	4.4			0.25	4.4	2.1	U	U	0.28	2.1	2.1	U	U	0.27	2.1	NT					NT				
Benzo(a)pyrene	210	15	na	3.6			0.21	3.6	2.1	U	U	0.24	2.1	2.1	U	U	0.23	2.1	NT					NT				
Benzo(b)fluoranthene	2100	150	na	7.9			0.35	7.9	2.1	U	U	0.4	2.1	2.1	U	U	0.39	2.1	NT					NT				
Benzo(g,h,i)perylene	1700000	170000	na	2.4			0.66	2.4	2.1	U	U	0.74	2.1	2.1	U	U	0.72	2.1	NT					NT				
Benzo(k)fluoranthene	21000	1500	na	2			0.33	2	2.1	U	U	0.37	2.1	2.1	U	U	0.36	2.1	NT					NT				
Chrysene	210000	15000	na	4.7			0.3	4.7	2.1	U	U	0.34	2.1	2.1	U	U	0.33	2.1	NT					NT				
Dibenz(a,h)anthracene	210	15	na	1.9	U	U	0.64	1.9	2.1	U	U	0.72	2.1	2.1	U	U	0.7	2.1	NT					NT				
Fluoranthene	2200000	230000	na	9.8			0.32	9.8	2.1	U	U	0.36	2.1	2.1	U	U	0.35	2.1	NT					NT				
Fluorene	2200000	230000	na	1.9	U	U	0.5	1.9	2.1	U	U	0.56	2.1	2.1	U	U	0.55	2.1	NT					NT				
Indeno(1,2,3-cd)pyrene	2100	150	na	2.9			0.6	2.9	2.1	U	U	0.68	2.1	2.1	U	U	0.66	2.1	NT					NT				
Naphthalene	18000	3600	na	1.8	JB	B	0.72	1.8	1.5	JB	B	0.82	1.5	1.5	JB	B	0.79	1.5	NT					NT				
Phenanthrene	1700000	170000	na	7.6			0.29	7.6	2.1	U	U	0.32	2.1	2.1	U	U	0.31	2.1	NT					NT				
Pyrene	1700000	170000	na	9.5			0.42	9.5	2.1	U	U	0.48	2.1	2.1	U	U	0.46	2.1	NT					NT				
SVOCs (ug/kg)																												
bis(2-Ethylhexyl)phthalate	120000	35000	na	190	U	U	12	190	210	U	U	14	210	210	U	U	14	210	NT					NT				
Fluoranthene	2200000	230000	na	11	J	J	6.1	11	210	U	U	6.9	210	210	U	U	6.7	210	NT					NT				
Phenanthrene	1700000	170000	na	10	J	J	5.8	10	210	U	U	6.5	210	210	U	U	6.4	210	NT					NT				
Pyrene	1700000	170000	na	7.9	J	J	5.7	7.9	210	U	U	6.4	210	210	U	U	6.2	210	NT					NT				
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	0.389	J	J	0.155	0.389	NT					NT					NT					NT				
4,4'-DDE	5100	1400	na	0.462	BJ	B	0.154	0.462	NT					NT					NT					NT				
4,4'-DDT	7000	1700	na	0.733	U	U	0.259	0.733	NT					NT					NT					NT				
Endosulfan II	na	na	na	0.733	U	U	0.262	0.733	NT					NT					NT					NT				
Endrin aldehyde	na	na	na	0.733	U	U	0.37	0.733	NT					NT					NT					NT				
Methoxychlor	310000	31000	na	0.567	J	J	0.559	0.567	NT					NT					NT					NT				
PCBs (mg/kg)																												
PCB-1254	0.74	0.022	na	0.0366	U	UJ	0.0108	0.0366	0.0415	U	UJ	0.0122	0.0415	0.0403	U	UJ	0.0119	0.0403	NT					NT				
Explosives (mg/kg)																												
Nitroglycerin	6.2	0.61	na	0.12	J	J	0.11	0.12	0.374	U	U	0.124	0.374	0.363	U	U	0.121	0.363	0.324	U	U	0.108	0.324	0.382	U	U	0.127	0.382
Herbicides (ug/kg)	None detected																											
Metals (mg/kg)																												
Aluminum	99000	7700	40041	12600			6.1	12600	32900			6.9	32900	22500			6.7	22500	NT					NT				
Antimony	41	3.1	na	0.549	U	UL	0.19	0.549	0.36	B	B	0.21	0.36	0.605	U	UL	0.2	0.605	NT					NT				
Arsenic	1.6	0.39	15.8	1.46		L	0.38	1.46	0.6	B	L	0.44	0.6	0.846		L	0.42	0.846	NT					NT				
Barium	19000	1500	209	102			0.37	102	56.3			0.42	56.3	29.4			0.4	29.4	NT					NT				
Beryllium	200	16	1.02	0.73			0.0379	0.73	0.765			0.043	0.765	0.701			0.0418	0.701	NT					NT				
Calcium	na	na	na	415		J	3.1	415	141		J	3.5	141	81.7		J	3.4	81.7	NT					NT				
Chromium	150000	12000	65.3	27.5			0.41	27.5	36.1			0.47	36.1	27.2			0.45	27.2	NT					NT				
Cobalt	30	2.3	72.3	10.3		J	0.89	10.3	6.1	B	J	1	6.1	4.6	B	J	0.98	4.6	NT					NT				
Copper	4100	310	53.5	5.39			0.68	5.39	15.9			0.77	15.9	8.03			0.75	8.03	NT					NT				
Iron	72000	5500	50962	15500		J	3.7	15500	41600		J	4.2	41600	27500		J	4.1	27500	NT					NT				
Lead	800	400	26.8	18.7			0.033	18.7	13.6			0.038	13.6	4.89			0.037	4.89	NT					NT				
Magnesium	na	na	na	587		J	2.6	587	1100		J	2.9	1100	832		J	2.9	832	NT					NT				
Manganese	2300	180	2543	998		J	0.061	998	129		J	0.07	129	122		J	0.068	122	NT					NT				
Mercury	4.3	1.0	0.13	0.03	B	J	0.0218	0.03	0.0674			0.0247	0.0674	0.033	B	J	0.024	0.033	NT					NT				
Nickel	2000	150	62.8	7.16		J	1	7.16	12.3		J	1.1	12.3	7.85		J	1.1	7.85	NT					NT				
Potassium	na	na	na	673			37	673	1340			42	1340	1490			40	1490	NT					NT				
Silver	510	39	na	1.1	U	U	0.54	1.1	0.71	B	B	0.61	0.71	1.21	U	U	0.6	1.21	NT					NT				
Sodium	na	na	na	22.1		B	4.1	22.1	21	B	B	4.7	21	14	B	B	4.5	14	NT					NT				
Thallium	1	0.78	2.11	0.14	B	J	0.033	0.14	0.17	B	J	0.038	0.17	0.097	B	J	0.036	0.097	NT					NT				
Vanadium	520	39	108	32.6		J	0.64	32.6	73.3		J	0.72	73.3	23.8		J	0.7	23.8	NT					NT				
Zinc	31000	2300	202	23.8		J	0.39	23.8	42.9		J	0.45	42.9	29		J	0.43	29	NT					NT				
Misc.																												
Total Organic Carbon (mg/kg)	na	na	na	16700			186	16700	NT					975	B	J	205	975	NT					NT				
pH	na	na	na	5.52		J	+/-0.1	5.52	NT					5.23		J	+/-0.1	5.23	NT					NT				
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	na	na	na	0.239			0.105	0.19	0.032	U		0.032	0.19	0.036	U		0.036	0.19	0.034	U		0.034	0.19	0.033	U		0.033	0.19
2,3,7,8-TCDD	0.03	0.00052	na	0.136	X	J	0.067	0.13	0.047	U		0.047	0.13	0.054	U		0.054	0.13	0.036	U		0.036	0.13	0.049	U		0.049	0.13
1,2,3,7,8-PECDD	na	na	na	0.614			0.086	0.19	0.055	U		0.055	0.19	0.064	U		0.064	0.19	0.096	U		0.096	0.19	0.073	U		0.073	0.19
1,2,3,6,7,8-HXCDD	460	100	na	4.764			0.077	0.57	0.068	U		0.068	0.57	0.065	U		0.065	0.57	0.544			0.063	0.57	0.057	U		0.057	0.57
1,2,3,7,8,9-HXCDD	460	100	na	4.651			0.082	0.68	0.069	U		0.069	0.68	0.067	U		0.067	0.68	0.701			0.065	0.68	0.284			0.059	0.68
1,2,3,4,6,7,8-HPCDD	na	na	na	132			0.173	0.63	2.364			0.073	0.63	1.706			0.098	0.63	21.48			0.091	0.63	7.573			0.09	0.63
OCDD	na	na	na	1527	B		0.091	6.86	286.1	B		0.061	6.86	649.2	B		0.063	6.86	1155	B		0.046	6.86	1944	B		0.039	6.86
1,2,3,7,8-PECDF	na	na	na	0.248			0.058	0.28	0.04	U		0.04	0.28	0.048	U		0.048	0.28	0.039	U		0.039	0.28	0.047	U		0.047	0.28
2,3,4,7,8-PECDF	na	na	na	0.192			0.062	0.56	0.044	U		0.044	0.56	0.053	U		0.053	0.56	0.043	U		0.043	0.56	0.051	U		0.051	0.56
1,2,3,4,7,8-HXCDF	na	na	na	0.976			0.058	0.34	0.051	U		0.051	0.34	0.052	U		0.052	0.34	0.211			0.049	0.34	0.045	U		0.045	0.34
1,2,3,6,7,8-HXCDF	na	na	na	4.151	I	J	0.055	0.49	0.05	U		0.05	0.49	0.051	U		0.051	0.49	0.428	I	J	0.048	0.49	0.044	U		0.044	0.49
2,3,4,6,7,8-HXCDF	na	na	na	0.452			0.07	0.47	0.062	U		0.062	0.47	0.064	U		0.064	0.47	0.06	U		0.06	0.47	0.055	U		0.055	0.47
1,2,3,7,8,9-HXCDF	na	na	na	0.078	U		0.078	0.25	0.067	U		0.067	0.25	0.068	U		0.068	0.25	0.065	U		0.065	0.25	0.059	U		0.059	0.25
1,2,3,4,6,7,8-HPCDF	na	na	na	21.56			0.098	0.33	0.281			0.031	0.33	0.045	U		0.045	0.33	2.581			0.04	0.33	0.38			0.035	0.33
1,2,3,4,7,8,9-HPCDF	na	na	na	1.254			0.141	0.5	0.042	U		0.042	0.5	0.061	U		0.061	0.5	0.054	U		0.054	0.5	0.048	U		0.048	0.5
OCDF	na	na	na	67.39	B		0.078	0.79	0.938	B	B	0.049	0.79	0.333	B	B	0.048	0.79	6.751	B		0.064	0.79	0.915	B	B	0.036	0.79
TOTAL TCDD	na	na	na	0.52			0.067		0.047	U		0.047		0.054	U		0.054		0.036	U		0.036		0.049	U		0.049	
TOTAL PECDD	na	na	na	0.614			0.086		0.055	U		0.055		0.064	U		0.064		0.096	U		0.096		0.073	U		0.073	
TOTAL HXCDD	na	na	na	35.61			0.077		0.068	U		0.068		0.065	U		0.065		1.244			0.063		1.346			0.057	
TOTAL HPCDD	na	na	na	225.9			0.173		4.582			0.073		3.357			0.098		43.53			0.091		15.46			0.09	
TOTAL TCDF	na	na	na	0.664			0.039		0.032	U		0.032		0.036	U		0.036		0.034	U		0.034		0.033	U		0.033	
TOTAL PECDF	na	na	na	3.237			0.058		0.04	U		0.04		0.048	U		0.048		0.172			0.039		0.047	U		0.047	
TOTAL HXCDF	na	na	na	24.39			0.055		0.05	U		0.05		0.051	U		0.051		2.199			0.048		0.044	U		0.044	
TOTAL HPCDF	na	na	na	62.46			0.098		0.751			0.031		0.045	U		0.045		6.227			0.04		0.843			0.035	

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-10
Analytes Detected in SWMU 48 Soil Samples - 2002 RFI
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Analyte	Sample ID Sample Date Sample Depth			48SB09C 6/24/02 8-10					48SB10A 6/24/02 0-0.5					48SB10B 6/24/02 4-6					48SB10C 6/24/02 8-10				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																							
Acetone	63000000	6100000	na	NT					4.8	U	UJ	2.1	4.8	5.4	U	UJ	2.4	5.4	5.6	U	UJ	2.5	5.6
Toluene	4500000	500000	na	NT					4.8	U	U	0.31	4.8	5.4	U	U	0.35	5.4	5.6	U	U	0.36	5.6
PAHs (ug/kg)																							
2-Methylnaphthalene	410000	31000	na	NT					9.6			0.61	9.6	2	U	U	0.69	2	0.95	J	B	0.71	0.95
Anthracene	17000000	1700000	na	NT					0.71	J	J	0.2	0.71	2	U	U	0.22	2	2.1	U	U	0.23	2.1
Benz(a)anthracene	2100	150	na	NT					2.9			0.24	2.9	2	U	U	0.27	2	2.1	U	U	0.28	2.1
Benzo(a)pyrene	210	15	na	NT					2.4			0.2	2.4	2	U	U	0.23	2	2.1	U	U	0.24	2.1
Benzo(b)fluoranthene	2100	150	na	NT					4.7			0.34	4.7	2	U	U	0.39	2	2.1	U	U	0.4	2.1
Benzo(g,h,i)perylene	1700000	170000	na	NT					1.4	J	J	0.63	1.4	2	U	U	0.72	2	2.1	U	U	0.74	2.1
Benzo(k)fluoranthene	21000	1500	na	NT					1.5	J	J	0.31	1.5	2	U	U	0.36	2	2.1	U	U	0.37	2.1
Chrysene	210000	15000	na	NT					4.6			0.29	4.6	2	U	U	0.33	2	2.1	U	U	0.34	2.1
Dibenz(a,h)anthracene	210	15	na	NT					0.74	J	J	0.61	0.74	2	U	U	0.69	2	2.1	U	U	0.72	2.1
Fluoranthene	2200000	230000	na	NT					6.3			0.31	6.3	2	U	U	0.35	2	2.1	U	U	0.36	2.1
Fluorene	2200000	230000	na	NT					1.1	J	J	0.48	1.1	2	U	U	0.54	2	2.1	U	U	0.56	2.1
Indeno(1,2,3-cd)pyrene	2100	150	na	NT					1.6	J	J	0.58	1.6	2	U	U	0.65	2	2.1	U	U	0.68	2.1
Naphthalene	18000	3600	na	NT					6.7	B		0.7	6.7	1.2	JB	B	0.79	1.2	1.6	JB	B	0.82	1.6
Phenanthrene	1700000	170000	na	NT					18			0.28	18	2	U	U	0.31	2	2.1	U	U	0.32	2.1
Pyrene	1700000	170000	na	NT					8.2			0.41	8.2	2	U	U	0.46	2	2.1	U	U	0.48	2.1
SVOCs (ug/kg)																							
bis(2-Ethylhexyl)phthalate	120000	35000	na	NT					130	J	B	12	130	200	U	U	14	200	210	U	U	14	210
Fluoranthene	2200000	230000	na	NT					7.9	J	J	5.9	7.9	200	U	U	6.6	200	210	U	U	6.9	210
Phenanthrene	1700000	170000	na	NT					13	J	J	5.6	13	200	U	U	6.3	200	210	U	U	6.5	210
Pyrene	1700000	170000	na	NT					8.1	J	J	5.5	8.1	200	U	U	6.2	200	210	U	U	6.4	210
Pesticides (ug/kg)																							
4,4'-DDD	7200	2000	na	NT					0.347	J	J	0.15	0.347	NT					NT				
4,4'-DDE	5100	1400	na	NT					0.525	BJ	B	0.149	0.525	NT					NT				
4,4'-DDT	7000	1700	na	NT					2.31			0.251	2.31	NT					NT				
Endosulfan II	na	na	na	NT					0.418	J	J	0.253	0.418	NT					NT				
Endrin aldehyde	na	na	na	NT					0.55	J	J	0.358	0.55	NT					NT				
Methoxychlor	310000	31000	na	NT					0.708	U	U	0.54	0.708	NT					NT				
PCBs (mg/kg)																							
PCB-1254	0.74	0.022	na	NT					0.0769		J	0.0104	0.0769	0.04	U	UJ	0.0118	0.04	0.0415	U	UJ	0.0122	0.0415
Explosives (mg/kg)																							
Nitroglycerin	6.2	0.61	na	0.389	U	U	0.129	0.389	0.15	J	J	0.106	0.15	0.36	U	U	0.12	0.36	0.374	U	U	0.124	0.374
Herbicides (ug/kg)	None detected																						
Metals (mg/kg)																							
Aluminum	99000	7700	40041	NT					10900			5.9	10900	24200			6.6	24200	24100			6.9	24100
Antimony	41	3.1	na	NT					0.531	U	UL	0.18	0.531	0.6	U	UL	0.2	0.6	0.623	U	UL	0.21	0.623
Arsenic	1.6	0.39	15.8	NT					2.62		L	0.37	2.62	0.6	U	UL	0.42	0.6	0.623	U	UL	0.44	0.623
Barium	19000	1500	209	NT					73.3			0.36	73.3	164			0.4	164	63.4			0.42	63.4
Beryllium	200	16	1.02	NT					0.44	B	J	0.0366	0.44	0.745			0.0414	0.745	1			0.043	1
Calcium	na	na	na	NT					15900		J	3	15900	26.8		B	3.4	26.8	16.8		B	3.5	16.8
Chromium	150000	12000	65.3	NT					30.7			0.4	30.7	17.6			0.45	17.6	27.6			0.47	27.6
Cobalt	30	2.3	72.3	NT					5.98		J	0.86	5.98	58.2		J	0.97	58.2	18.6		J	1	18.6
Copper	4100	310	53.5	NT					6.59			0.66	6.59	13.7			0.74	13.7	15.7			0.77	15.7
Iron	72000	5500	50962	NT					12100		J	3.6	12100	**81800**		**J**	4	81800	**61400**		**J**	4.2	61400
Lead	800	400	26.8	NT					17			0.032	17	19.9			0.036	19.9	10.5			0.038	10.5
Magnesium	na	na	na	NT					1640		J	2.5	1640	1040		J	2.8	1040	1480		J	2.9	1480
Manganese	2300	180	2543	NT					248		J	0.059	248	2070		J	0.067	2070	508		J	0.07	508
Mercury	4.3	1.0	0.13	NT					0.037	B	J	0.021	0.037	0.047	B	J	0.0238	0.047	0.0623	U	U	0.0247	0.0623
Nickel	2000	150	62.8	NT					5.54		J	0.97	5.54	11.3		J	1.1	11.3	13		J	1.1	13
Potassium	na	na	na	NT					642			36	642	1280			40	1280	1720			42	1720
Silver	510	39	na	NT					1.06	U	U	0.52	1.06	1.2	B	B	0.59	1.2	0.87	B	B	0.61	0.87
Sodium	na	na	na	NT					19	B	B	4	19	19	B	B	4.5	19	16	B	B	4.7	16
Thallium	1	0.78	2.11	NT					0.14	B	J	0.032	0.14	0.27	B	J	0.036	0.27	0.21	B	J	0.038	0.21
Vanadium	520	39	108	NT					30.8		J	0.61	30.8	55.9		J	0.69	55.9	63.7		J	0.72	63.7
Zinc	31000	2300	202	NT					24.4		J	0.38	24.4	42.2		J	0.43	42.2	53.9		J	0.45	53.9
Misc.																							
Total Organic Carbon (mg/kg)	na	na	na	NT					NT					NT					NT				
pH	na	na	na	NT					NT					NT					NT				
Dioxins/Furans (ng/kg)																							
2,3,7,8-TCDF	na	na	na	0.028	U		0.028	0.19	70	U				0.04	U		0.04	0.19	0.028	U		0.028	0.19
2,3,7,8-TCDD	0.03	0.00052	na	0.052	U		0.052	0.13	0.366	X	J	0.043	0.13	0.078	U		0.078	0.13	0.05	U		0.05	0.13
1,2,3,7,8-PECDD	na	na	na	0.057	U		0.057	0.19	0.869			0.081	0.19	0.103	U		0.103	0.19	0.057	U		0.057	0.19
1,2,3,6,7,8-HXCDD	460	100	na	0.049	U		0.049	0.57	6.14			0.073	0.57	0.089	U		0.089	0.57	0.054	U		0.054	0.57
1,2,3,7,8,9-HXCDD	460	100	na	0.051	U		0.051	0.68	5.901			0.076	0.68	0.091	U		0.091	0.68	0.055	U		0.055	0.68
1,2,3,4,6,7,8-HPCDD	na	na	na	1.448			0.052	0.63	159			0.111	0.63	2.766			0.115	0.63	7.592			0.08	0.63
OCDD	na	na	na	302.8	B		0.05	6.86	3244	B		0.057	6.86	422.5	B		0.098	6.86	1408	B		0.039	6.86
1,2,3,7,8-PECDF	na	na	na	0.036	U		0.036	0.28	0.045	U		0.045	0.28	0.06	U		0.06	0.28	0.038	U		0.038	0.28
2,3,4,7,8-PECDF	na	na	na	0.039	U		0.039	0.56	0.102			0.049	0.56	0.066	U		0.066	0.56	0.042	U		0.042	0.56
1,2,3,4,7,8-HXCDF	na	na	na	0.035	U		0.035	0.34	1.088			0.06	0.34	0.058	U		0.058	0.34	0.04	U		0.04	0.34
1,2,3,6,7,8-HXCDF	na	na	na	0.034	U		0.034	0.49	3.495	I	J	0.058	0.49	0.057	U		0.057	0.49	0.038	U		0.038	0.49
2,3,4,6,7,8-HXCDF	na	na	na	0.043	U		0.043	0.47	0.394	X	J	0.073	0.47	0.071	U		0.071	0.47	0.048	U		0.048	0.47
1,2,3,7,8,9-HXCDF	na	na	na	0.046	U		0.046	0.25	0.078	U		0.078	0.25	0.076	U		0.076	0.25	0.052	U		0.052	0.25
1,2,3,4,6,7,8-HPCDF	na	na	na	0.083	X	J	0.031	0.33	27.16			0.089	0.33	0.066	U		0.066	0.33	0.125	X	J	0.029	0.33
1,2,3,4,7,8,9-HPCDF	na	na	na	0.042	U		0.042	0.5	1.09			0.121	0.5	0.09	U		0.09	0.5	0.04	U		0.04	0.5
OCDF	na	na	na	0.279	B	B	0.038	0.79	86.22	B		0.052	0.79	0.252	B	B	0.074	0.79	0.238	B	B	0.029	0.79
TOTAL TCDD	na	na	na	0.052	U		0.052		0.648			0.043		0.078	U		0.078		0.05	U		0.05	
TOTAL PECDD	na	na	na	0.057	U		0.057		0.869			0.081		0.103	U		0.103		0.057	U		0.057	
TOTAL HXCDD	na	na	na	0.049	U		0.049		38.29			0.073		0.089	U		0.089		0.054	U		0.054	
TOTAL HPCDD	na	na	na	3.203			0.052		269.4			0.111		6.227			0.115		14.09			0.08	
TOTAL TCDF	na	na	na	0.028	U		0.028		0.674			0.038		0.04	U		0.04		0.028	U		0.028	
TOTAL PECDF	na	na	na	0.036	U		0.036		5.03			0.045		0.06	U		0.06		0.038	U		0.038	
TOTAL HXCDF	na	na	na	0.034	U		0.034		22.85			0.058		0.057	U		0.057		0.038	U		0.038	
TOTAL HPCDF	na	na	na	0.031	U		0.031		79.41			0.089		0.066	U		0.066		0.029	U		0.029	

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-10
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
µg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
B (organics) = Blank contamination. Value detected in sample and associated blank.
B (metals) = Value <MRL and >MDL and is considered estimated.
I (dioxins) = Indicates possible interference presence. Estimated concentration.
J (organics) = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
X (dioxins) = Ion abundance ratio outside acceptable range. Value reported as EMPC.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
L = Estimated concentration bias low.
U = Analyte not detected.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 2-11
Analytes Detected in SWMU 49 Soil Samples - 2002 RFI

Analyte			Sample ID	49SB02A					49SB02B					49SB02C					49SB02D					49SS01				
			Sample Date	6/24/02					6/24/02					6/24/02					6/24/02					6/24/02				
			Sample Depth	0-0.5					4-6					8-10					17-19					0-0.5				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																												
Acetone	63000000	6100000	na	5.2	U	UJ	2.3	5.2	NT					NT					NT					100		B	2.5	100
PAHs (ug/kg)																												
2-Methylnaphthalene	410000	31000	na	3		B	0.67	3	2	U	U	0.68	2	12000			0.73	12000	11000			0.69	11000	5.1		B	0.63	5.1
Acenaphthene	3300000	340000	na	2	U	U	1.1	2	15		B	1.1	15	1100			1.2	1100	720			1.1	720	1.9	U	U	1	1.9
Acenaphthylene	1700000	170000	na	2	U	U	0.26	2	7.1			0.27	7.1	290			0.29	290	210			0.27	210	1.9	U	U	0.25	1.9
Anthracene	17000000	1700000	na	2	U	U	0.22	2	3.4			0.22	3.4	480			0.24	480	130			0.22	130	1	J	J	0.21	1
Benz(a)anthracene	2100	150	na	2	U	U	0.26	2	1.5	J	J	0.27	1.5	34			0.29	34	2	U	U	0.27	2	6.1			0.25	6.1
Benzo(a)pyrene	210	15	na	2	U	U	0.22	2	1.3	J	J	0.23	1.3	2.2	U	U	0.24	2.2	2	U	U	0.23	2	4.9			0.21	4.9
Benzo(b)fluoranthene	2100	150	na	2	U	U	0.38	2	1.8	J	J	0.39	1.8	21			0.41	21	2	U	U	0.39	2	9.9			0.36	9.9
Benzo(g,h,i)perylene	1700000	170000	na	2	U	U	0.7	2	1.3	J	J	0.71	1.3	2.2	U	U	0.76	2.2	2	U	U	0.72	2	2.9			0.66	2.9
Benzo(k)fluoranthene	21000	1500	na	2	U	U	0.34	2	0.96	J	J	0.35	0.96	2.2	U	U	0.38	2.2	2	U	U	0.35	2	4.2			0.33	4.2
Chrysene	210000	15000	na	1.1	J	J	0.32	1.1	6.6			0.32	6.6	68			0.35	68	2	U	U	0.32	2	6.6			0.3	6.6
Dibenz(a,h)anthracene	210	15	na	2	U	U	0.67	2	2	U	U	0.69	2	2.2	U	U	0.74	2.2	2	U	U	0.69	2	2.3			0.64	2.3
Fluoranthene	2200000	230000	na	1.3	J	J	0.34	1.3	16			0.35	16	120			0.37	120	35			0.35	35	14			0.32	14
Fluorene	2200000	230000	na	2	U	U	0.53	2	2	U	U	0.54	2	1400		J	0.57	1400	1200			0.54	1200	1.5	J	J	0.5	1.5
Indeno(1,2,3-cd)pyrene	2100	150	na	2	U	U	0.63	2	2	U	U	0.65	2	2.2	U	U	0.69	2.2	2	U	U	0.65	2	3.4			0.6	3.4
Naphthalene	18000	3600	na	2.6	B	B	0.76	2.6	1.7	JB	B	0.78	1.7	2100	B		0.84	2100	1800	B		0.79	1800	3.8	B	B	0.73	3.8
Phenanthrene	1700000	170000	na	2.6			0.3	2.6	14			0.31	14	4900			0.33	4900	2400			0.31	2400	14			0.29	14
Pyrene	1700000	170000	na	1.1	J	J	0.45	1.1	32			0.46	32	360			0.49	360	150			0.46	150	1.9	U	U	0.42	1.9
SVOCs (ug/kg)																												
Benzoic acid	2.5E+08	24000000	na	970	U	U	130	970	NT					NT					NT					210	J	B	130	210
Fluoranthene	2200000	230000	na	200	U	U	6.4	200	NT					NT					NT					13	J	J	6.1	13
Phenanthrene	1700000	170000	na	200	U	U	6.1	200	NT					NT					NT					13	J	J	5.8	13
Pyrene	1700000	170000	na	200	U	U	6	200	NT					NT					NT					10	J	J	5.7	10
Pesticides (ug/kg)																												
4,4'-DDD	7200	2000	na	0.776	U	U	0.164	0.776	NT					NT					NT					1.01			0.156	1.01
4,4'-DDE	5100	1400	na	0.776	U	U	0.163	0.776	NT					NT					NT					0.344	BJ	B	0.155	0.344
delta-BHC	na	na	na	0.687	BJ	B	0.135	0.687	NT					NT					NT					0.738	U	U	0.128	0.738
Dieldrin	110	30	na	9.45		K	0.477	9.45	NT					NT					NT					0.738	U	U	0.454	0.738
Endosulfan II	na	na	na	7.22			0.277	7.22	NT					NT					NT					0.738	U	U	0.263	0.738
Endosulfan sulfate	na	na	na	6.64			0.244	6.64	NT					NT					NT					0.738	U	U	0.232	0.738
Endrin aldehyde	na	na	na	0.776	U	U	0.392	0.776	NT					NT					NT					0.723	J	J	0.373	0.723
Endrin	18000	1800	na	0.776	U	U	0.186	0.776	NT					NT					NT					0.757			0.177	0.757
PCBs (mg/kg)																												
PCB-1232	0.54	0.14	na	0.0388	U	UJ	0.0215	0.0388	9.23		J	0.221	9.23	0.708		J	0.0236	0.708	0.0399	U	UJ	0.0222	0.0399	0.0368	U	UJ	0.0205	0.0368
Explosives (mg/kg)	None detected																											
Herbicides (ug/kg)	None detected																											
Metals (mg/kg)																												
Aluminum	99000	7700	40041	28900			6.4	28900	28200			6.6	28200	33700			7	33700	22100			6.6	22100	10200			6.1	10200
Arsenic	1.6	0.39	15.8	0.771		L	0.41	0.771	0.597	U	UL	0.42	0.597	0.51	B	L	0.45	0.51	0.599	U	UL	0.42	0.599	0.52	B	L	0.39	0.52
Barium	19000	1500	209	53			0.39	53	54.5			0.4	54.5	56.8			0.43	56.8	33.2			0.4	33.2	92.1			0.37	92.1
Beryllium	200	16	1.02	0.663			0.0402	0.663	0.679			0.0412	0.679	0.697			0.0439	0.697	**1.28**			0.0413	1.28	0.54	B	J	0.0382	0.54
Calcium	na	na	na	474		J	3.3	474	133		J	3.3	133	258		J	3.6	258	223		J	3.3	223	321		J	3.1	321
Chromium	150000	12000	65.3	24.9			0.44	24.9	25.8			0.45	25.8	23.1			0.48	23.1	16.7			0.45	16.7	13.6			0.41	13.6
Cobalt	30	2.3	72.3	5.6	B	J	0.94	5.6	5.3	B	J	0.97	5.3	6.3	B	J	1	6.3	19.1		J	0.97	19.1	5.75		J	0.9	5.75
Copper	4100	310	53.5	13.9			0.72	13.9	13.7			0.74	13.7	15.3			0.79	15.3	3.85			0.74	3.85	5.49			0.68	5.49
Iron	72000	5500	50962	32600		J	3.9	32600	31300		J	4	31300	34500		J	4.3	34500	23200		J	4	23200	9060		J	3.7	9060
Lead	800	400	26.8	15.4			0.035	15.4	14.8			0.036	14.8	**34.1**			0.039	34.1	4.8			0.036	4.8	18.4			0.033	18.4
Magnesium	na	na	na	1080		J	2.8	1080	962		J	2.8	962	1120		J	3	1120	1430		J	2.8	1430	512		J	2.6	512
Manganese	2300	180	2543	130		J	0.065	130	131		J	0.067	131	107		J	0.071	107	286		J	0.067	286	570		J	0.062	570
Mercury	4.3	1.0	0.13	0.0665			0.0231	0.0665	0.053	B	J	0.0237	0.053	0.071			0.0252	0.071	0.0599	U	U	0.0237	0.0599	0.048	B	J	0.0219	0.048
Nickel	2000	150	62.8	10.7		J	1.1	10.7	9.9		J	1.1	9.9	12		J	1.2	12	14.9		J	1.1	14.9	5.33		J	1	5.33
Potassium	na	na	na	1120			39	1120	1040			40	1040	1420			43	1420	3850			40	3850	508			37	508
Silver	510	39	na	0.59	B	B	0.57	0.59	1.19	U	U	0.59	1.19	1.27	U	U	0.63	1.27	1.2	U	U	0.59	1.2	1.11	U	U	0.54	1.11
Sodium	na	na	na	18	B	B	4.3	18	16	B	B	4.5	16	42.1		J	4.8	42.1	20	B	B	4.5	20	17	B	B	4.1	17
Thallium	1	0.78	2.11	0.13	B	J	0.035	0.13	0.092	B	J	0.036	0.092	0.14	B	J	0.038	0.14	0.067	B	J	0.036	0.067	0.1	B	J	0.033	0.1
Vanadium	520	39	108	63.9		J	0.67	63.9	60.3		J	0.69	60.3	69.8		J	0.74	69.8	13.9		J	0.69	13.9	20.3		J	0.64	20.3
Zinc	31000	2300	202	39.7		J	0.42	39.7	37.2		J	0.43	37.2	50.1		J	0.46	50.1	25		J	0.43	25	23.3		J	0.4	23.3
Misc.																												
TOC (mg/kg)	na	na	na	NT					NT					NT					8590			202	1200	17600			187	1110
pH	na	na	na	NT					NT					NT					4.85		J	+/-0.1	+/-0.1	4.81		J	+/-0.1	+/-0.1
TPH (mg/kg)	100	100	na	NT					NT					NT					3500			260000	790000	NT				
Dioxins/Furans (ng/kg)																												
2,3,7,8-TCDF	na	na	na	0.076	U		0.076	0.19	0.031	U		0.031	0.19	1.223	U		1.223	0.19	0.428	U		0.428	0.19	0.419	U		0.419	0.19
2,3,7,8-TCDD	18	4.5	na	0.028	U		0.028	0.13	0.051	U		0.051	0.13	1.135	U		1.135	0.13	0.44	U		0.44	0.13	0.081	U		0.081	0.13
1,2,3,7,8-PECDD	na	na	na	0.043	U		0.043	0.19	0.073	U		0.073	0.19	2.066	U		2.066	0.19	1.032	U		1.032	0.19	0.168	U		0.168	0.19
1,2,3,4,7,8-HXCDD	na	na	na	0.299		J	0.047	0.53	0.099	U	UJ	0.099	0.53	3.593	U		3.593	0.53	2.538	U		2.538	0.53	0.717		J	0.135	0.53
1,2,3,6,7,8-HXCDD	na	na	na	0.727			0.038	0.57	0.08	U		0.08	0.57	2.814	U		2.814	0.57	1.988	U		1.988	0.57	1.222			0.109	0.57
1,2,3,7,8,9-HXCDD	na	na	na	0.776			0.039	0.68	0.082	U		0.082	0.68	2.726	U		2.726	0.68	1.926	U		1.926	0.68	1.408			0.112	0.68
1,2,3,4,6,7,8-HPCDD	na	na	na	30.02			0.065	0.63	6.561			0.159	0.63	69.66		J	6.279	0.63	12.37			2.363	0.63	28.16			0.143	0.63
OCDD	na	na	na	4030	B		0.086	6.86	1630	B		0.287	6.86	14930		J	7.206	6.86	188.3	B		3.747	6.86	1027	B		0.109	6.86
2,3,4,7,8-PECDF	na	na	na	0.032	U		0.032	0.56	0.065	U		0.065	0.56	2.074	U		2.074	0.56	0.585	U		0.585	0.56	0.249			0.093	0.56
1,2,3,4,7,8-HXCDF	na	na	na	0.217			0.032	0.34	0.078	U		0.078	0.34	7.7	U		7.7	0.34	2.248	U		2.248	0.34	0.56			0.098	0.34
1,2,3,6,7,8-HXCDF	na	na	na	0.768	I	J	0.032	0.49	0.076	U		0.076	0.49	7.493	U		7.493	0.49	2.188	U		2.188	0.49	0.938	I	J	0.096	0.49
2,3,4,6,7,8-HXCDF	na	na	na	0.11	X	J	0.04	0.47	0.095	U		0.095	0.47	8.766	U		8.766	0.47	2.559	U		2.559	0.47	0.255	X	J	0.12	0.47
1,2,3,7,8,9-HXCDF	na	na	na	0.042	U		0.042	0.25	0.102	U		0.102	0.25	8.829	U		8.829	0.25	2.578	U		2.578	0.25	0.128	U		0.128	0.25
1,2,3,4,6,7,8-HPCDF	na	na	na	3.188			0.029	0.33	0.291			0.077	0.33	3.341	U		3.341	0.33	1.12	U		1.12	0.33	3.974			0.101	0.33
1,2,3,4,7,8,9-HPCDF	na	na	na	0.273			0.04	0.5	0.104	U		0.104	0.5	4.318	U		4.318	0.5	1.447	U		1.447	0.5	0.138	U		0.138	0.5
OCDF	na	na	na	10.1	B		0.093	0.79	1.423	B	B	0.457	0.79	12.02	U		12.02	0.79	5.075	U		5.075	0.79	10.16	B		0.083	0.79
TOTAL TCDD	na	na	na	0.028	U		0.028		0.051	U		0.051		1.135	U		1.135		5.603			0.44		0.081	U		0.081	
TOTAL PECDD	na	na	na	0.043	U		0.043		0.073	U		0.073		2.066	U		2.066		1.032	U		1.032		0.168	U		0.168	
TOTAL HXCDD	na	na	na	4.008			0.038		0.08	U		0.08		2.726	U		2.726		1.926	U		1.926		13			0.109	
TOTAL HPCDD	na	na	na	55.94			0.065		12.88			0.159		121.3		J	6.279		22.13			2.363		59.79			0.143	
TOTAL TCDF	na	na	na	0.07			0.023		0.031	U		0.031		1.223	U		1.223		0.428	U		0.428		1.905			0.062	
TOTAL PECDF	na	na	na	0.343			0.029		0.06	U		0.06		1.982	U		1.982		0.559	U		0.559		1.221			0.085	
TOTAL HXCDF	na	na	na	3.62			0.032		0.076	U		0.076		7.493	U		7.493		2.188	U		2.188		3.66			0.096	
TOTAL HPCDF	na	na	na	9.681			0.029		1.124			0.077		3.341	U		3.341		1.12	U		1.12		8.766			0.101	

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-11
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
<u>12</u>	**<u>J</u>**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
µg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
B (organics) = Blank contamination. Value detected in sample and associated blank.
B (metals) = Value <MRL and >MDL and is considered estimated.
I (dioxins) = Indicates possible interference presence. Estimated concentration.
J (organics) = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.
X (dioxins) = Ion abundance ratio outside acceptable range. Value reported as EMPC.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
U = Analyte not detected.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 2-12
Analytes Detected in SWMU 48 and 49 Groundwater Samples - 2006 Groundwater Data Report

Analyte	Sample ID Sample Date		**48MW1** **4/13/06**					**48MW2** **4/13/06**					**48MW3** **4/13/06**					**48MW4** **4/11/06**				
	MCL	**tw-SL**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																						
1,1,1-Trichloroethane	200	750	1.3		J	*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*
1,1-Dichloroethane	na	2.4	1.3		J	*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*
1,1-Dichloroethene	7	26	0.55	J	J	*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*
2-Butanone	na	490	5	U		*2.5*	*5*	4.5	J	B	*2.5*	*5*	5	U		*2.5*	*5*	5	U		*2.5*	*5*
Acetone	na	1200	25	U		*5*	*25*	61.5		B	*5*	*25*	25	U		*5*	*25*	25	U		*5*	*25*
Carbon tetrachloride	5	0.39	1	U		*0.5*	*1*	29.2			*0.5*	*1*	51.2			*0.5*	*1*	1	U		*0.5*	*1*
Chloroform	80	0.19	1	U		*0.5*	*1*	5.9		B	*0.5*	*1*	5.5		B	*0.5*	*1*	1	U		*0.5*	*1*
cis-1,2-Dichloroethene	70	2.8	0.71	J	J	*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*	1	U		*0.5*	*1*
Tetrachloroethene	5	0.072	1.1		J	*0.5*	*1*	1.1		J	*0.5*	*1*	0.54	J	J	*0.5*	*1*	0.66	J	J	*0.5*	*1*
Trichloroethene	5	0.44	5.5			*0.5*	*1*	3			*0.5*	*1*	7.4			*0.5*	*1*	1	U		*0.5*	*1*
PAHs (ug/L)	None detected																					
SVOCs (ug/L)	None detected																					
Pesticides (ug/L)	None detected																					
PCBs (ug/L)	None detected																					
Explosives (ug/L)	None detected																					
Metals (ug/L)																						
Aluminum	50	16000	606			*16*	*200*	2630			*16*	*200*	82.6	J	B	*16*	*200*	113	J	B	*16*	*200*
Antimony	6	0.6	2.2	U		*2.2*	*5*	2.2	U		*2.2*	*5*	4.3	J	B	*2.2*	*5*	2.2	U		*2.2*	*5*
Barium	2000	290	105	J	J	*0.5*	*200*	615			*0.5*	*200*	50.4	J	J	*0.5*	*200*	167	J	J	*0.5*	*200*
Beryllium	4	1.6	1.8	J	B	*0.7*	*4*	2	J	B	*0.7*	*4*	2.2	J	B	*0.7*	*4*	2.1	J	B	*0.7*	*4*
Calcium	na	na	67400			*26*	*1000*	89700			*26*	*1000*	102000			*26*	*1000*	58600			*26*	*1000*
Chromium	100	1600	1.7	J	J	*0.5*	*10*	6.4	J	J	*0.5*	*10*	1	J	J	*0.5*	*10*	0.86	J	J	*0.5*	*10*
Cobalt	na	0.47	0.4	U		*0.4*	*50*	1.3	J	B	*0.4*	*50*	0.4	U		*0.4*	*50*	0.4	U		*0.4*	*50*
Copper	1300	62	0.8	U		*0.8*	*25*	0.83	J	B	*0.8*	*25*	0.8	U		*0.8*	*25*	0.8	U		*0.8*	*25*
Iron	300	1100	617			*7.5*	*300*	2960			*7.5*	*300*	8.9	J	B	*7.5*	*300*	62.8	J	B	*7.5*	*300*
Lead	15	na	2	J	B	*1.2*	*5*	1.3	J	B	*1.2*	*5*	2.7	J	B	*1.2*	*5*	1.2	U		*1.2*	*5*
Magnesium	na	na	35300			*5.8*	*5000*	44800			*5.8*	*5000*	42800			*5.8*	*5000*	49600			*5.8*	*5000*
Manganese	50	32	10.3	J	J	*0.2*	*15*	50.7			*0.2*	*15*	1.8	J	B	*0.2*	*15*	2.6	J	B	*0.2*	*15*
Nickel	na	30	1.2	J	J	*1.1*	*40*	4.9	J	J	*1.1*	*40*	1.1	U		*1.1*	*40*	1.1	U		*1.1*	*40*
Potassium	na	na	2020	J	J	*36*	*5000*	1690	J	J	*36*	*5000*	1230	J	J	*36*	*5000*	1600	J	J	*36*	*5000*
Selenium	50	7.8	3.2	J	J	*2.4*	*10*	2.4	J	J	*2.4*	*10*	5.2	J	J	*2.4*	*10*	2.4	U		*2.4*	*10*
Sodium	na	na	13700			*77*	*5000*	311	J	B	*77*	*5000*	1030	J	B	*77*	*5000*	8230		L	*77*	*5000*
Vanadium	na	7.8	1.3	J	B	*0.6*	*50*	6.3	J	B	*0.6*	*50*	0.91	J	B	*0.6*	*50*	0.6	U		*0.6*	*50*
Zinc	5000	470	3	J	J	*0.8*	*20*	11.7	J	J	*0.8*	*20*	0.8	U		*0.8*	*20*	1.4	J	J	*0.8*	*20*
Dioxins/Furans (ug/L)																						
2,3,7,8-TCDF	na	na	0.00727	U	UJ	*0.00727*	*0.00727*	0.00772	U		*0.00772*	*0.00772*	0.00671	U		*0.00671*	*0.00671*	0.00334	U		*0.00334*	*0.00334*
2,3,7,8-TCDD	0.03	0.00052	0.0075	U		*0.0075*	*0.0075*	0.00856	U		*0.00856*	*0.00856*	0.00675	U		*0.00675*	*0.00675*	0.00403	U		*0.00403*	*0.00403*
1,2,3,7,8-PECDD	na	na	0.00528	U	UJ	*0.00528*	*0.00528*	0.0283	A	J	*NA*	*NA*	0.0112	A	J	*NA*	*NA*	0.00658	U		*0.00658*	*0.00658*
1,2,3,4,7,8-HXCDD	na	na	0.00876	U		*0.00876*	*0.00876*	0.0106	A	J	*NA*	*NA*	0.0123	U		*0.0123*	*0.0123*	0.0111	U		*0.0111*	*0.0111*
1,2,3,6,7,8-HXCDD	na	na	0.00807	U		*0.00807*	*0.00807*	0.00929	U		*0.00929*	*0.00929*	0.0113	U		*0.0113*	*0.0113*	0.0102	U		*0.0102*	*0.0102*
1,2,3,7,8,9-HXCDD	na	na	0.00887	U		*0.00887*	*0.00887*	0.0102	U		*0.0102*	*0.0102*	0.0125	U		*0.0125*	*0.0125*	0.0112	U		*0.0112*	*0.0112*
1,2,3,4,6,7,8-HPCDD	na	na	0.0126	U	UJ	*0.0126*	*0.0126*	0.0331	A	J	*NA*	*NA*	0.0168	A	J	*NA*	*NA*	0.0156	U		*0.0156*	*0.0156*
OCDD	na	na	0.0213	U		*0.0213*	*0.0213*	0.0352	U		*0.0352*	*0.0352*	0.0242	U		*0.0242*	*0.0242*	0.0309	U		*0.0309*	*0.0309*
1,2,3,7,8-PECDF	na	na	0.00292	U		*0.00292*	*0.00292*	0.00461	U		*0.00461*	*0.00461*	0.00307	U		*0.00307*	*0.00307*	0.00334	U		*0.00334*	*0.00334*
2,3,4,7,8-PECDF	na	na	0.00285	U		*0.00285*	*0.00285*	0.0045	U		*0.0045*	*0.0045*	0.003	U		*0.003*	*0.003*	0.00326	U		*0.00326*	*0.00326*
1,2,3,4,7,8-HXCDF	na	na	0.00493	U		*0.00493*	*0.00493*	0.00386	U		*0.00386*	*0.00386*	0.00598	U		*0.00598*	*0.00598*	0.00479	U		*0.00479*	*0.00479*
1,2,3,6,7,8-HXCDF	na	na	0.00434	U		*0.00434*	*0.00434*	0.0034	U		*0.0034*	*0.0034*	0.00527	U		*0.00527*	*0.00527*	0.00422	U		*0.00422*	*0.00422*
2,3,4,6,7,8-HXCDF	na	na	0.00492	U		*0.00492*	*0.00492*	0.00385	U		*0.00385*	*0.00385*	0.00596	U		*0.00596*	*0.00596*	0.00478	U		*0.00478*	*0.00478*
1,2,3,7,8,9-HXCDF	na	na	0.00588	U		*0.00588*	*0.00588*	0.0046	U		*0.0046*	*0.0046*	0.00713	U		*0.00713*	*0.00713*	0.00572	U		*0.00572*	*0.00572*
1,2,3,4,6,7,8-HPCDF	na	na	0.00636	U		*0.00636*	*0.00636*	0.00746	U		*0.00746*	*0.00746*	0.00601	U		*0.00601*	*0.00601*	0.00741	U		*0.00741*	*0.00741*
1,2,3,4,7,8,9-HPCDF	na	na	0.00824	U		*0.00824*	*0.00824*	0.00967	U		*0.00967*	*0.00967*	0.00778	U		*0.00778*	*0.00778*	0.0096	U		*0.0096*	*0.0096*
OCDF	na	na	0.0135	U		*0.0135*	*0.0135*	0.0261	U		*0.0261*	*0.0261*	0.0191	U		*0.0191*	*0.0191*	0.0168	U		*0.0168*	*0.0168*
TOTAL TCDD	na	na	0.0075	U		*0.0075*	*0.0075*	0.00856	U		*0.00856*	*0.00856*	0.00675	U		*0.00675*	*0.00675*	0.00403	U		*0.00403*	*0.00403*
TOTAL PECDD	na	na	0.00528	U		*0.00528*	*0.00528*	0.0283			*NA*	*NA*	0.00112			*NA*	*NA*	0.00658	U		*0.00658*	*0.00658*
TOTAL HXCDD	na	na	0.00887	U		*0.00887*	*0.00887*	0.0106			*NA*	*NA*	0.0125	U		*0.0125*	*0.0125*	0.0112	U		*0.0112*	*0.0112*
TOTAL HPCDD	na	na	0.0126	U		*0.0126*	*0.0126*	0.0331			*NA*	*NA*	0.0168			*NA*	*NA*	0.0156	U		*0.0156*	*0.0156*
TOTAL TCDF	na	na	0.00727	U		*0.00727*	*0.00727*	0.00772	U		*0.00772*	*0.00772*	0.00671	U		*0.00671*	*0.00671*	0.00334	U		*0.00334*	*0.00334*
TOTAL PECDF	na	na	0.00292	U		*0.00292*	*0.00292*	0.00461	U		*0.00461*	*0.00461*	0.00307	U		*0.00307*	*0.00307*	0.00334	U		*0.00334*	*0.00334*
TOTAL HXCDF	na	na	0.00588	U		*0.00588*	*0.00588*	0.0046	U		*0.0046*	*0.0046*	0.00713	U		*0.00713*	*0.00713*	0.00572	U		*0.00572*	*0.00572*
TOTAL HPCDF	na	na	0.00824	U		*0.00824*	*0.00824*	0.00967	U		*0.00967*	*0.00967*	0.00778	U		*0.00778*	*0.00778*	0.0096	U		*0.0096*	*0.0096*

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 2-12
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-SL exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-SLs for carcinogenic compounds are shown in red font.
tw-SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.
MCL Action Levels were used for copper and lead.
MCL Source: 2006 Edition of the Drinking Water Standards and Health Advisories. USEPA. August 2006.
tw-SL Source: ORNL Regional Screening Table. November 2011.
µg/L = micrograms per liter (parts per billion).
NA = not applicable.
NT = analyte not tested.

Lab Q = Lab Data Qualifiers
A (dioxins) = Value <MRL and >MDL and is considered estimated.
J = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
L = Estimated concentration bias low.
UJ = Estimated concentration non-detect.

3.0 FIELD INVESTIGATION PROGRAM

A field sampling event was conducted by Shaw in 2007 based on the USEPA/VDEQ approved *MWP Addendum 019* (Shaw, 2007). This investigation was performed in order to obtain current analytical data for the sites to complete their characterization. Soil at SWMU 48 was considered sufficiently characterized to complete the RFI; however, additional groundwater data was needed. In addition to re-sampling the existing wells, four new wells were installed at the site to refine the delineation of elevated constituents detected in previous investigations at the site (specifically, CT and TCE). Additional surface soil, subsurface soil, and groundwater samples were collected at SWMU 49 for the same purpose. The data was used to perform human health and ecological risk assessments that serve as the basis for the proposed remediation for the site. Details of the investigation are presented in *Section 3.1*. Samples and chemical analyses performed in support of the investigation are presented in **Table 3-1**. Results from the investigation are discussed in *Section 4.1*.

A Supplemental Data Investigation was performed at SWMU 48 in 2010 to augment the 2007 RFI and visibly locate the ash layer within the SWMU 48 trenches via test pitting and characterize the concentrations of explosives in the soil above, within, and below the ash layer. Details of the investigation are presented in *Section 3.2*. Samples and chemical analyses performed in support of the investigation are presented in **Table 3-2**. Results from the investigation are discussed in *Section 3.2*.

Based upon the findings from the 2010 Supplemental Data Investigation, an interim measures remedial action was performed in the southern portion of SWMU 48 in 2011 to mitigate the potential threats to human health and the environment that existed from the ash layer and/or grossly-contaminated soil under the ash layer, as well as to mitigate the threat for a potential release of contaminants from ash layer to groundwater. Details of the interim measures are summarized in *Section 3.3*. Analytical results from the confirmation soil samples collected following the interim measures are discussed in *Section 4.2.1*.

Review of the 2007 RFI groundwater data indicated that further investigation was required to delineate the extent of chlorinated solvents in groundwater in the SWMU 48/49 area. In an effort to complete the RFI at these sites, four additional groundwater monitoring wells were installed to the south and east of the two sites. These four new wells and 10 existing wells were sampled in May 2013 to further define the extent of chlorinated solvents in groundwater. Details of the 2013 Supplemental RFI are summarized in *Section 3.4*. Analytical results from the groundwater samples collected are discussed in *Section 4.3.1*.

3.1 RFI, Shaw, 2007

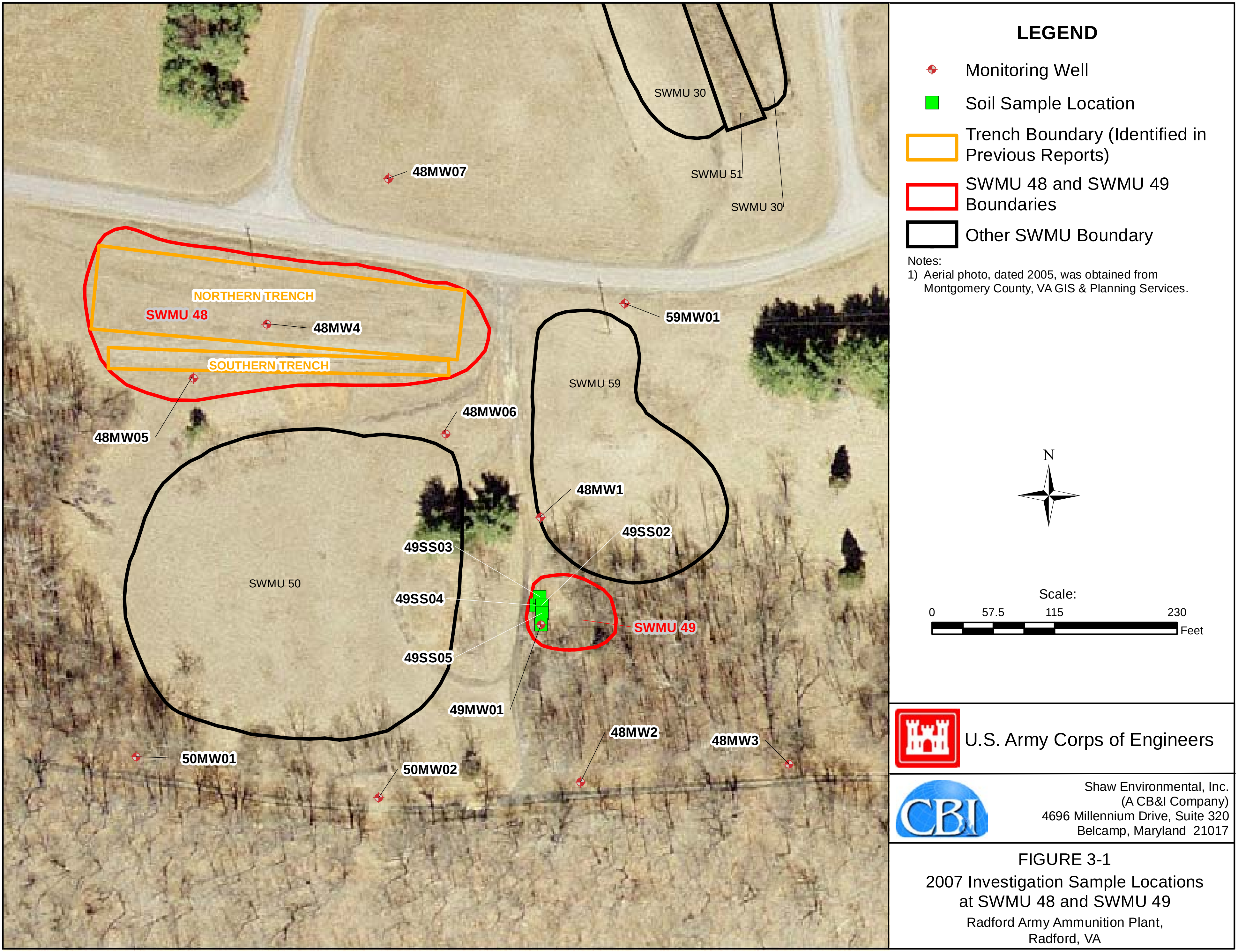
3.1.1 Soil

As presented in **Table 3-1**, four surface (49SS02, 49SS03, 49SS04, and 49SS05) and three subsurface soil samples (49MW01A, 49MW01B, and 49MW01C) were collected for chemical analysis. The three subsurface samples were collected from monitoring well boring 49MW01, and the four surface soil samples were collected to delineate an area of elevated arsenic detected in a 2002 investigation sample. Sample locations are depicted on **Figure 3-1**. As shown in **Table 3-1**, the soil samples were analyzed for TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans. Analytes detected above SLs in surface and subsurface soil are illustrated on **Figure 3-2** and **Figure 3-3**, respectively.

Table 3-1
2007 RFI Samples and Analyses

Media	Sampling ID	Depth (ft bgs)	Analytes
SWMU 49			
Surface Soil	49SS02	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	49SS03	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	49SS04	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	49SS05	0-0.5	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
Subsurface Soil	49MW01A	4-6	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	49MW01B	10-12	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	49MW01C	18-20	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
Groundwater	48MW1	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	48MW2	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	48MW3	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	48MW4	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	48MW05	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	48MW06	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	48MW07	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	49MW01	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	50MW01	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	50MW02	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate
	59MW01	na	TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate

Refer to **Appendix A-1, Table A-1** for the preparation and analytical methodologies used.



Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA GIS & Planning Services.

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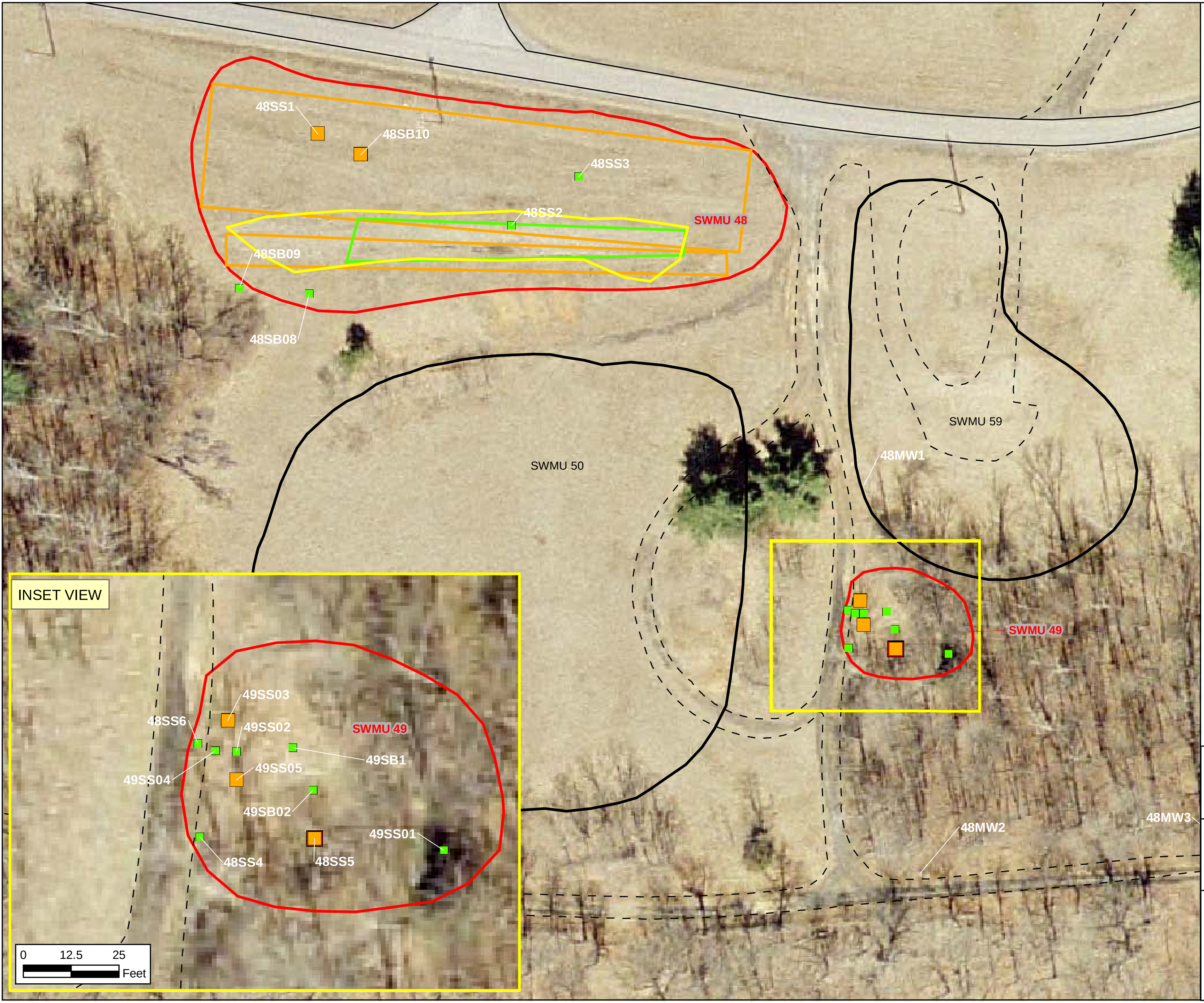
FIGURE 3-1
2007 Investigation Sample Locations
at SWMU 48 and SWMU 49
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-1_SWMU48_49_2007_Sample_Locations.mxd (4/8/2013)



ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-2_SWMU48_49_SS_Results.mxd (5/16/2013)

LEGEND

🟩	Soil Sample Location Result < r-SL and i-SL
🟧	Soil Sample Location Result >= r-SL
🟥	Soil Sample Location Result >= i-SL
- - -	Dirt Road
———	Paved Road
▭	Trench Boundary (Identified in Previous Reports)
▭	Southern Trench Boundary (GPS)
▭	Excavated Area
▭	SWMU 48 and SWMU 49 Boundaries
▭	Other SWMU Boundary

Notes:

1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Soil i-SL and r-SL values were obtained from the November 2011 USEPA Region III RBC Table.

Surface Soil Results

Sample ID	Surface Soil r-SL Exceedances	Surface Soil i-SL Exceedances
48SB10A	1 PCB	
48SS1	1 METAL	
48SS5	TPH	TPH
49SS03	1 PCB	
49SS05	1 PCB	

N

Scale:

0 30 60 120 Feet

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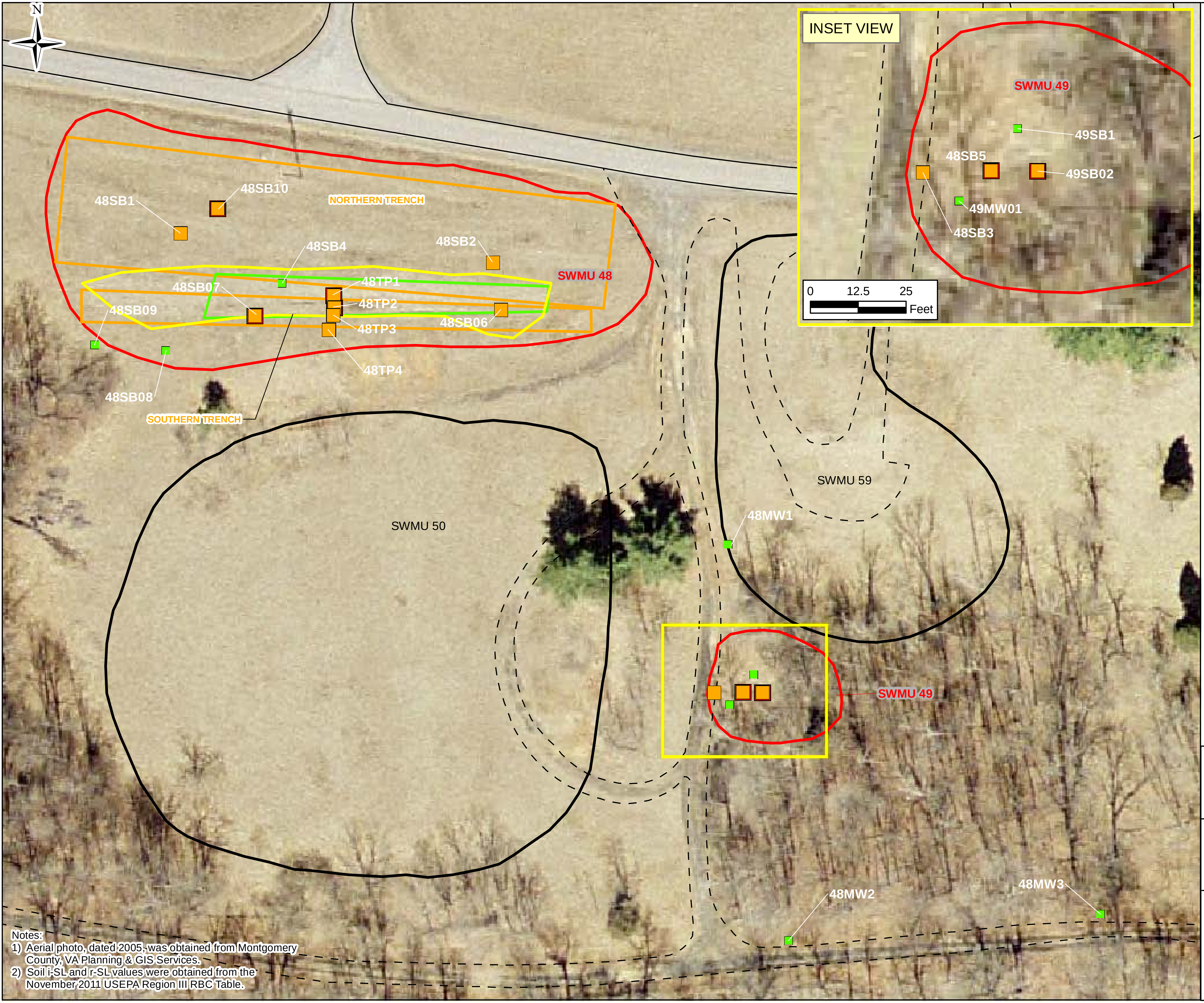
FIGURE 3-2
SWMU 48 and SWMU 49
Surface Soil Results

Radford Army Ammunition Plant,
Radford, VA



Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Soil i-SL and r-SL values were obtained from the November 2011 USEPA Region III RBC Table.

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-3_SWMU48_49_SB_Results.mxd (5/16/2013)

LEGEND

- 🟩 Soil Sample Location Result < r-SL and i-SL
- 🟧 Soil Sample Location Result >= r-SL
- 🟥 Soil Sample Location Result >= i-SL
- - - Dirt Road
- — Paved Road
- ▭ Trench Boundary (Identified in Previous Reports)
- ▭ Southern Trench Boundary (GPS)
- ▭ Excavated Area
- ▭ SWMU48 and 49 Boundaries
- ▭ Other SWMU Boundary

Subsurface Soil Results

Sample ID	Subsurface Soil r-SL Exceedances	Subsurface Soil i-SL Exceedances
48TP1	2 EXPLOSIVES	1 EXPLOSIVE
48TP2	2 METALS	
48TP3	2 METALS	
48TP4	2 METALS	
48SB1 (RVFS*1)	1 METAL	
48SB5A19	2 SVOCS, TPH	1 SVOC, TPH
48SB6C	1 EXPLOSIVE	
48SB7A	2 EXPLOSIVES	1 EXPLOSIVE
48SB7B	1 EXPLOSIVE	
48SB10B	1 METAL	1 METAL
48SB10C	1 METAL	
48SB2 (RVFS*3)	1 SVOC	
48SB3 (RVFS*6)	1 SVOC	
49SB02B	1 PCB	1 PCB
49SB02C	1 PCB	1 PCB
49SB02D	TPH	TPH

Scale:
0 30 60 120
Feet

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FIGURE 3-3
SWMU 48 and SWMU 49 Subsurface Soil Results

Radford Army Ammunition Plant,
Radford, VA

3.1.2 Groundwater

Eleven groundwater samples (48MW1, 48MW2, 48MW3, 48MW4, 48MW05, 48MW06, 48WM07, 49MW01, 50MW01, 50MW02, and 59MW01) were collected for chemical analysis; four from existing wells and seven from newly-installed wells (**Figure 3-1**). As shown in **Table 3-1**, groundwater samples were analyzed for TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate.

Boring logs and well construction diagrams for the existing and newly-installed wells are presented in **Appendix B-1**. The well purge/field water quality measurement forms for the 2007 sampling event are included in **Appendix B-3**. Groundwater sample locations are illustrated on **Figure 3-1** and the sample detections above SLs are illustrated on **Figure 3-4**.

3.1.3 Global Positioning System Activities

Sample location coordinates and elevations were obtained for soil samples 49SS02, 49SS03, 49SS04, and 49SS05 and wells 48MW05, 48MW06, 48MW07, 49MW01, 50MW01, 50MW02, and 59MW01 using a Trimble Geo XH Global Positioning System. The Geo XH system was used to obtain real-time position information with sub-meter accuracy and elevations at 1.5 to 2 times the horizontal accuracy. Horizontal position information was recorded in the U.S. State [Virginia (South)] Plane Coordinate System (measured in U.S. survey feet) using the North American Datum of 1983. The vertical control was measured in feet using the National Geodetic Vertical Datum of 1988. Position information will be entered into the Environmental Restoration Information System database. Sample location coordinates and elevations are presented in **Appendix C-1**.

3.1.4 Quality Assurance

The accuracy and integrity of 2007 RFI data were ensured through the implementation of internal quality control (QC) measures in accordance with *MWP Addendum 019* (Shaw, 2007), as approved by USEPA Region III and the VDEQ. Quality assurance (QA) and QC activities, including field QC, laboratory QC, data management, and data validation were integrated into the investigation program to meet data quality objectives (DQOs) established for the RFI. The data were evaluated for each of the DQO indicators in **Appendix A-2, Table A-3** and found to meet the pre-established goals. Qualified data did not impact the data quality of the RFI. Complete details of the RFI QA/QC analysis and activities are presented in **Appendix A-2**. Chemical data validation reports and analytical data are provided in **Appendix A-3**.

3.1.5 Modifications to the Sampling Plan

In some cases, modifications to the Work Plan are necessary to adjust for field conditions as they occur during field sampling. However, no adjustments to *MWP Addendum 019* (Shaw, 2007) were necessary during sampling activities at SWMUs 48 and 49.

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-4_SWMU48_49_50_59_2007_GW_Results.mxd (11/19/2013)

LEGEND

- ● Groundwater Sample Location Result < MCL and tw-RBC
- ● Groundwater Sample Location Result >= tw-RBC
- ● Groundwater Sample Location Result >= MCL
- - - - Dirt Road
- ── Paved Road
- 🟧 Trench Boundary (Identified in Previous Reports)
- 🟩 Southern Trench Boundary (GPS)
- 🟥 SWMU 48, 49, 50, and 59 Boundaries

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Groundwater MCL values were obtained from the 2011 Edition of the Drinking Water Standards and Health Advisories, USEPA, Winter 2011. Groundwater tw-SL values were obtained from the November 2011 USEPA Region III RBC table.

Groundwater Results

Sample ID	Groundwater tw-SL Exceedances	Groundwater MCL Exceedances
48MW1	1 VOC	
48MW2	7 METALS, 2 VOCs	4 METALS, 2 VOCs
48MW3	2 VOCs	2 VOCs
48MW05	11 METALS, 1 VOC	8 METALS
48MW06	10 METALS, 3 VOCs	5 METALS
48MW07 *	1 METAL	2 METALS
49MW01	1 METAL, 1 VOC	2 METALS
50MW01	11 METALS	4 METALS
50MW02	4 METALS, 1 SVOC, 3 VOCs	4 METALS, 1 SVOC
59MW01		2 METALS

* Groundwater exceedances at 48MW07 were limited to three metals. Aluminum and iron only exceeded secondary MCLs and manganese only exceeded its tw-SL (but was below its S-MCL).

Scale:
0 32.5 65 130
Feet

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FIGURE 3-4
SWMUs 48, 49, 50, and 59 2007 Groundwater Results

Radford Army Ammunition Plant,
Radford, VA

3.2 Supplemental Data Investigation, Shaw, 2010

A supplemental data investigation was performed in 2010 to augment the 2007 RFI. The objectives of the supplemental data investigation was to attempt to visibly locate the ash layer within the SWMU 48 trenches via test pitting and characterize the concentrations of explosives in the soil above, within, and below the ash layer.

Test pits were advanced downward and through the ash layer, where present. The test pit investigation was a dynamic investigation designed to establish the boundaries of the ash layer. Within the southern and northern trenches, several test pits were advanced and logged until the ash layer visually terminated within or was no longer present in the outlying test pits. As shown on **Figure 3-5**, the initially excavated test pit, 48TP1, was advanced to intersect 1998 RFI subsurface sample 48SB07A, where 2,4,6-TNT was detected at a concentration of 935 milligrams per kilogram (mg/kg).

Test pits were visually inspected and logged by a staff geologist as soil was unearthed. Test pits typically consisted of light brown, Silty Sand (SM) fill overlying a reddish-brown native Lean Clay (CL). A dark gray to black layer of very moist black ash was encountered in several test pits, including 48TP1 through 48TP5, 48TP8, 48TP10, and 48TP13, typically around 0.5 to 3.5 ft bgs. The thickness of the ash layer generally ranged from approximately 0.3 to 2.0 ft thick. Lenses of plastics, roofing materials, and asphalt debris were encountered in test pits 48TP6, 48TP9, 48TP11, and 48TP12. An unknown green clayey substance was encountered at approximately 6.5 ft bgs in test pit 48TP6. This substance was found in approximately 12-inch by 12-inch blocks, contained by weathered cardboard and wrapped in plastic bags. Based on further excavations, this material was confined to 48TP6.

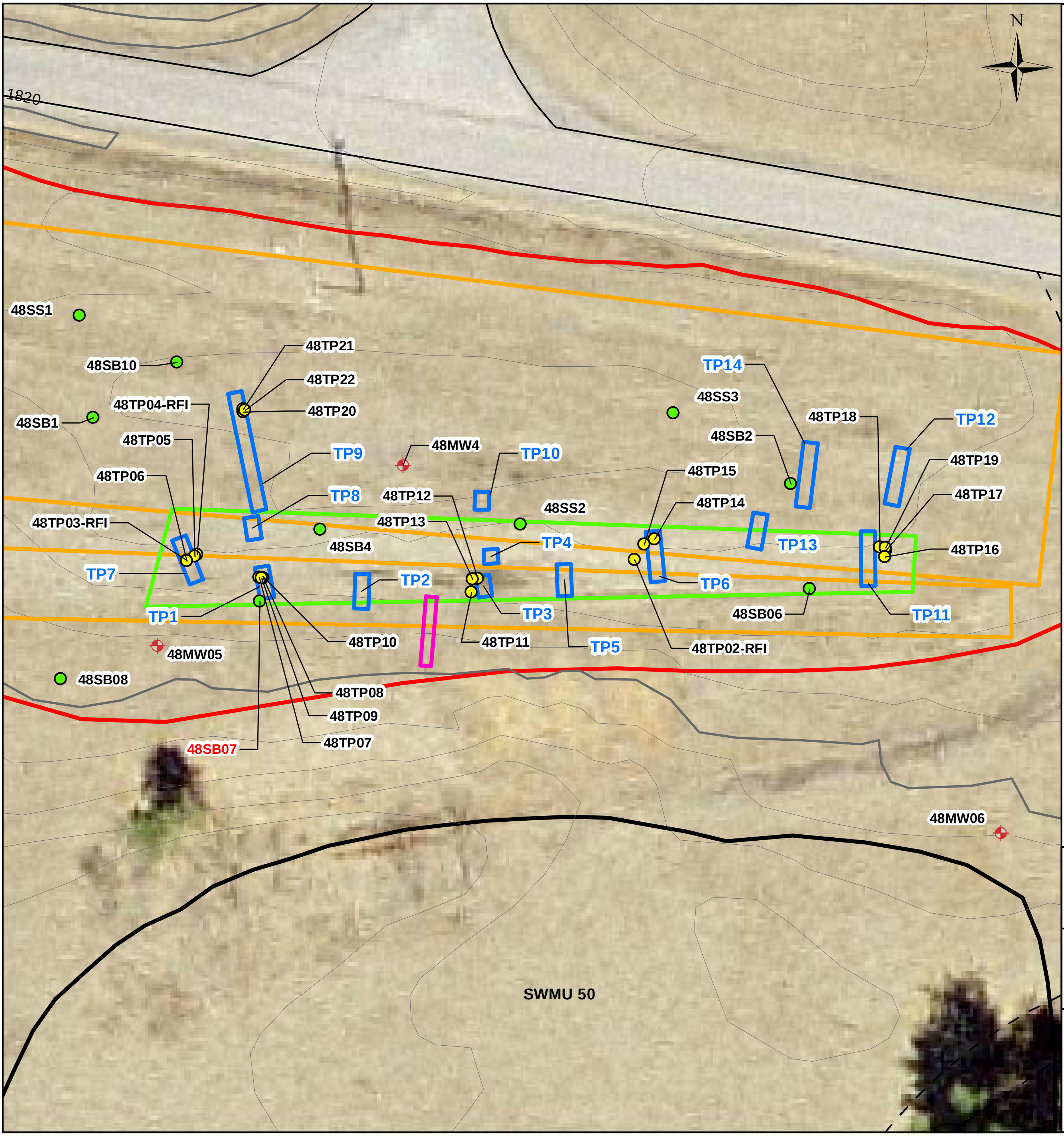
As shown in **Table 3-2**, 18 subsurface soil samples were analyzed for TAL metals and explosives, and three subsurface soil composite samples were analyzed for TCLP SVOCs, TCLP metals, explosives, corrosivity as pH, reactivity, and ignitability.

Table 3-2
2010 Supplemental Data Investigation Samples and Analyses

Media	Number of Samples	Analysis	Objective
Subsurface Soil	18	TAL metals, explosives	Characterize the concentrations of metals and explosives associated with the ash layer, if present
Subsurface Soil Composite	3	TCLP SVOCs, TCLP metals, explosives, corrosivity as pH, reactivity, and ignitability	Determine if excavated soil contains explosive or waste characteristic concentrations above TCLP regulatory limits

Results from the sampling event are tabulated in **Table 3-3** and summarized in **Table 3-4**. The TCLP results are presented in **Table 3-5**. Additional information on the 2010 Supplemental Data Investigation is provided in the *SWMU 48 Supplemental RCRA Facility Investigation Data Report* (Shaw, 2010) contained in **Appendix B-4**.

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-5_SWMU48_Prev_Sample_Locations.mxd



LEGEND

● Test Pit Delineation Soil Sample Location

⌖ Monitoring Well Location

● Soil Sample Location

– – – Dirt Road

—— Paved Road

—— 2 ft Contour Line

—— 10 ft Contour Line

▭ 2010 Test Pit Boundary

▭ 1998 RFI Test Pit Boundary

▭ Southern Trench Boundary (GPS)

▭ Trench Boundary (Identified in Previous Reports)

▭ SWMU 48 Boundary

▭ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

Scale:
0 20 40 80
Feet

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FIGURE 3-5
SWMU 48 Previous Investigation
Sample Locations
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Radford, VA

Table 3-3
SWMU 48 Supplemental Data Investigation Soil Sample Results - 2010
Page 1 of 4

Analyte			Sample ID	48TP02-RFI					48TP03-RFI					48TP04-RFI					48TP05					48TP07				
			Sample Date	3/18/10					3/18/10					3/18/10					3/18/10					3/18/10				
			Sample Depth	6-7					1-2					3-4					5-6					2.35-2.5				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Explosives (mg/kg)																												
1,3,5-Trinitrobenzene	2700	220	na	0.13	J PG	J	0.01	0.25	0.25	U		0.01	0.25	0.25	U		0.01	0.25	0.25	U		0.009	0.25	0.25	U		0.01	0.25
1,3-Dinitrobenzene	6.2	0.61	na	0.25	U		0.004	0.25	0.25	U		0.004	0.25	0.25	U		0.004	0.25	0.25	U		0.004	0.25	0.25	U		0.004	0.25
2,4,6-Trinitrotoluene	79	19	na	0.25	U		0.019	0.25	0.056	J	J	0.019	0.25	0.18	J	J	0.019	0.25	0.25	U		0.019	0.25	0.25	U		0.019	0.25
2,4-Dinitrotoluene	5.5	1.6	na	0.022	J	J	0.005	0.25	0.079	J	J	0.005	0.25	1.6			0.005	0.25	0.13	J	J	0.005	0.25	0.25	U		0.005	0.25
2,6-Dinitrotoluene	62	6.1	na	0.25	U		0.007	0.25	0.074	J	J	0.007	0.25	0.19	J	J	0.007	0.25	0.054	J	J	0.007	0.25	0.11	J	J	0.007	0.25
2-amino-4,6-Dinitrotoluene	200	15	na	0.25	U		0.012	0.25	0.25	U		0.012	0.25	0.25	U		0.012	0.25	0.25	U		0.012	0.25	0.25	U		0.012	0.25
4-amino-2,6-Dinitrotoluene	190	15	na	0.25	U		0.01	0.25	0.038	J	J	0.01	0.25	0.01	J PG	J	0.01	0.25	0.022	J	J	0.009	0.25	0.25	U		0.01	0.25
HMX	4900	380	na	0.25	U		0.012	0.25	0.25	U		0.012	0.25	0.025	J	J	0.012	0.25	0.25	U		0.012	0.25	0.25	U		0.012	0.25
Nitroglycerin	6.2	0.61	na	0.5	U		0.015	0.5	0.051	J PG	J	0.015	0.5	1.2	PG	J	0.015	0.5	0.17	J	J	0.015	0.5	0.5	U		0.015	0.5
Metals (mg/kg)																												
Antimony	41	3.1	na	0.99	U	UL	0.33	0.99	1.2		L	0.31	0.92	3.2		L	0.29	0.87	1.5		L	0.31	0.93	1.9		L	0.27	0.81
Arsenic	1.6	0.39	15.8	0.82	U	UL	0.25	0.82	4		L	0.23	0.77	3.5		L	0.22	0.72	4.1		L	0.23	0.77	6.4		L	0.2	0.68
Barium	19000	1500	209	0.96		K	0.16	0.49	114		K	0.15	0.46	199		K	0.14	0.43	142		K	0.15	0.46	144		K	0.14	0.41
Beryllium	200	16	1.02	0.16	U		0.016	0.16	0.79			0.015	0.15	0.69			0.014	0.14	0.91			0.015	0.15	0.69			0.014	0.14
Cadmium	80	7	0.69	**9.2**			0.082	0.25	**1.1**			0.077	0.23	**6.3**			0.072	0.22	**1.8**			0.077	0.23	**2.2**			0.068	0.2
Chromium	150000	12000	65.3	2.7		L	0.33	0.99	31.2		L	0.31	0.92	48.5		L	0.29	0.87	34.5		L	0.31	0.93	32.7		L	0.27	0.81
Cobalt	30	2.3	72.3	9			0.16	0.49	4.6			0.15	0.46	6.8			0.14	0.43	6			0.15	0.46	4.9			0.14	0.41
Copper	4100	310	53.5	**81800**	**B RLA**	**J**	247	822	31.7	B	J	0.23	0.77	**239**	**B**	**J**	0.22	0.72	**87.5**	**B**	**J**	0.23	0.77	**98**	**B**	**J**	0.2	0.68
Lead	800	400	26.8	**114000**	**B RLA**	**K**	98.7	329	**294**	**B**	**K**	0.092	0.31	**665**	**B**	**K**	0.087	0.29	**450**	**B**	**K**	0.093	0.31	**349**	**B**	**K**	0.081	0.27
Manganese	2300	180	2543	11.3			0.41	1.3	145			0.39	1.2	162			0.36	1.2	180			0.39	1.2	171			0.34	1.1
Mercury	4.3	1.0	0.13	0.024	J	J	0.014	0.066	**1.5**	**RLA**		0.026	0.12	**25.5**	**RLA**		0.31	1.4	**5.9**	**RLA**		0.11	0.49	**12.5**	**RLA**		0.29	1.4
Nickel	2000	150	62.8	10.7		J	0.16	0.49	25		J	0.15	0.46	22.7		J	0.14	0.43	23.3		J	0.15	0.46	16.9		J	0.14	0.41
Selenium	510	39	na	0.7		L	0.16	0.49	0.77		L	0.15	0.46	1.1		L	0.14	0.43	0.85		L	0.15	0.46	1.2		L	0.14	0.41
Silver	510	39	na	0.95			0.049	0.16	1.1			0.046	0.15	30	RLA		0.22	0.72	13.5			0.046	0.15	16.1	RLA		0.2	0.68
Thallium	1	0.78	2.11	0.25	U		0.082	0.25	0.23	U		0.077	0.23	0.22	U		0.072	0.22	0.23	U		0.077	0.23	0.12	J	J	0.068	0.2
Vanadium	520	39	108	3.3	U	UJ	0.99	3.3	24.4		J	0.92	3.1	15.2		J	0.87	2.9	24.9		J	0.93	3.1	24.4		J	0.81	2.7
Zinc	31000	2300	202	32.9	U G	UJ	9.9	32.9	40.4		J	0.92	3.1	**499**		**J**	0.87	2.9	143		J	0.93	3.1	**209**		**J**	0.81	2.7

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 3-3
SWMU 48 Supplemental Data Investigation Soil Sample Results - 2010
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Analyte			Sample ID	**48TP08**					**48TP08D**					**48TP09**					**48TP11**					**48TP12**				
			Sample Date	**3/18/10**					**3/18/10**					**3/18/10**					**3/18/10**					**3/18/10**				
			Sample Depth	**3.5-4**					**3.5-4**					**5-6**					**1-2**					**1-2**				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Explosives (mg/kg)																												
1,3,5-Trinitrobenzene	2700	220	na	0.62		J	*0.009*	*0.25*	0.14	J PG	J	*0.01*	*0.25*	0.25	U		*0.01*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*
1,3-Dinitrobenzene	6.2	0.61	na	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*
2,4,6-Trinitrotoluene	79	19	na	1.6		J	*0.019*	*0.25*	0.42		J	*0.019*	*0.25*	0.25	U		*0.019*	*0.25*	0.25	U		*0.019*	*0.25*	0.25	U		*0.019*	*0.25*
2,4-Dinitrotoluene	5.5	1.6	na	0.75		J	*0.005*	*0.25*	0.32		J	*0.005*	*0.25*	0.25	U		*0.005*	*0.25*	0.25	U		*0.005*	*0.25*	0.25	U		*0.005*	*0.25*
2,6-Dinitrotoluene	62	6.1	na	0.9		J	*0.007*	*0.25*	0.27		J	*0.007*	*0.25*	0.013	J	J	*0.007*	*0.25*	0.25	U		*0.007*	*0.25*	0.3	PG	J	*0.007*	*0.25*
2-amino-4,6-Dinitrotoluene	200	15	na	1.7		J	*0.012*	*0.25*	2.6		J	*0.012*	*0.25*	0.032	J	J	*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*
4-amino-2,6-Dinitrotoluene	190	15	na	0.43		J	*0.009*	*0.25*	0.45		J	*0.01*	*0.25*	0.25	U		*0.01*	*0.25*	0.25	U		*0.009*	*0.25*	0.13	J	J	*0.009*	*0.25*
HMX	4900	380	na	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*
Nitroglycerin	6.2	0.61	na	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*
Metals (mg/kg)																												
Antimony	41	3.1	na	1		L	*0.25*	*0.76*	0.36	J	L	*0.23*	*0.7*	0.77	U	UL	*0.26*	*0.77*	0.78	U	UL	*0.26*	*0.78*	0.78	U	UL	*0.26*	*0.78*
Arsenic	1.6	0.39	15.8	**112**		**L**	*0.19*	*0.63*	7.4		L	*0.17*	*0.58*	2.8		L	*0.19*	*0.64*	4		L	*0.2*	*0.65*	3.7		L	*0.19*	*0.65*
Barium	19000	1500	209	96.1		K	*0.13*	*0.38*	95.8		K	*0.12*	*0.35*	55.4		K	*0.13*	*0.39*	67.3		K	*0.13*	*0.39*	41.1		K	*0.13*	*0.39*
Beryllium	200	16	1.02	0.89			*0.013*	*0.13*	0.83			*0.012*	*0.12*	0.69			*0.013*	*0.13*	0.71			*0.013*	*0.13*	0.43			*0.013*	*0.13*
Cadmium	80	7	0.69	**1.1**		**J**	*0.063*	*0.19*	**0.71**		**J**	*0.058*	*0.17*	0.31			*0.064*	*0.19*	0.37			*0.065*	*0.2*	0.19			*0.065*	*0.19*
Chromium	150000	12000	65.3	52		L	*0.25*	*0.76*	23.5		L	*0.23*	*0.7*	26.7		L	*0.26*	*0.77*	26.7		L	*0.26*	*0.78*	22.9		L	*0.26*	*0.78*
Cobalt	30	2.3	72.3	8.5			*0.13*	*0.38*	7.1			*0.12*	*0.35*	4.6			*0.13*	*0.39*	14.8			*0.13*	*0.39*	6			*0.13*	*0.39*
Copper	4100	310	53.5	27.5	B	J	*0.19*	*0.63*	23.4	B	J	*0.17*	*0.58*	17.1	B	J	*0.19*	*0.64*	15.6	B	J	*0.2*	*0.65*	5.1		J	*0.19*	*0.65*
Lead	800	400	26.8	**105**	**B**	**K**	*0.076*	*0.25*	**106**	**B**	**K**	*0.07*	*0.23*	26.3	B	K	*0.077*	*0.26*	15.5	B	K	*0.078*	*0.26*	17.6	B	K	*0.078*	*0.26*
Manganese	2300	180	2543	456			*0.32*	*1*	356			*0.29*	*0.93*	130			*0.32*	*1*	429			*0.33*	*1*	327			*0.32*	*1*
Mercury	4.3	1.0	0.13	**2.1**	**RLA**	**J**	*0.032*	*0.15*	**0.71**		**J**	*0.01*	*0.047*	**0.31**			*0.011*	*0.051*	**0.15**			*0.011*	*0.052*	0.078			*0.011*	*0.052*
Nickel	2000	150	62.8	13.4		J	*0.13*	*0.38*	15.6		J	*0.12*	*0.35*	15.3		J	*0.13*	*0.39*	16.7		J	*0.13*	*0.39*	5.3		J	*0.13*	*0.39*
Selenium	510	39	na	1.1		L	*0.13*	*0.38*	0.73		L	*0.12*	*0.35*	0.72		L	*0.13*	*0.39*	0.51		L	*0.13*	*0.39*	0.64		L	*0.13*	*0.39*
Silver	510	39	na	3.1		J	*0.038*	*0.13*	1.8		J	*0.035*	*0.12*	0.49			*0.039*	*0.13*	0.097	J	J	*0.039*	*0.13*	0.049	J	J	*0.039*	*0.13*
Thallium	1	0.78	2.11	1.3		J	*0.063*	*0.19*	0.11	J	J	*0.058*	*0.17*	0.21			*0.064*	*0.19*	0.32			*0.065*	*0.2*	0.12	J	J	*0.065*	*0.19*
Vanadium	520	39	108	37.2		J	*0.76*	*2.5*	33.5		J	*0.7*	*2.3*	77.6		J	*0.77*	*2.6*	82.3		J	*0.78*	*2.6*	34.7		J	*0.78*	*2.6*
Zinc	31000	2300	202	158		J	*0.76*	*2.5*	170		J	*0.7*	*2.3*	45.1		J	*0.77*	*2.6*	45.9		J	*0.78*	*2.6*	20.1		J	*0.78*	*2.6*

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 3-3
SWMU 48 Supplemental Data Investigation Soil Sample Results - 2010
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Analyte			Sample ID	48TP13					48TP14					48TP14D					48TP15					48TP16				
			Sample Date	3/18/10					3/18/10					3/18/10					3/18/10					3/18/10				
			Sample Depth	3-4					2-3					2-3					8-9					1-2				
	i-SL	r-SL	Background	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Explosives (mg/kg)																												
1,3,5-Trinitrobenzene	2700	220	na	0.25	U		0.009	0.25	1.3	U		0.05	1.3	1.2	U		0.049	1.2	0.25	U		0.01	0.25	0.25	U		0.01	0.25
1,3-Dinitrobenzene	6.2	0.61	na	0.25	U		0.004	0.25	1.3	U		0.021	1.3	1.2	U		0.02	1.2	0.073	J PG	J	0.004	0.25	0.25	U		0.004	0.25
2,4,6-Trinitrotoluene	79	19	na	0.25	U		0.019	0.25	1.3	U		0.097	1.3	1.2	U		0.094	1.2	0.25	U		0.019	0.25	0.25	U		0.019	0.25
2,4-Dinitrotoluene	5.5	1.6	na	0.25	U		0.005	0.25	6.9	V		0.027	1.3	5.3	V		0.026	1.2	0.25	U		0.005	0.25	0.25	U		0.005	0.25
2,6-Dinitrotoluene	62	6.1	na	0.25	U		0.007	0.25	2.7			0.037	1.3	2.8			0.036	1.2	0.25	U		0.007	0.25	0.25	U		0.007	0.25
2-amino-4,6-Dinitrotoluene	200	15	na	0.25	U		0.012	0.25	1.3	U		0.063	1.3	1.2	U		0.061	1.2	0.25	U		0.012	0.25	0.25	U		0.012	0.25
4-amino-2,6-Dinitrotoluene	190	15	na	0.25	U		0.009	0.25	1.3	U		0.05	1.3	1.2	U		0.049	1.2	0.25	U		0.01	0.25	0.25	U		0.01	0.25
HMX	4900	380	na	0.25	U		0.012	0.25	1.3	U		0.061	1.3	1.2	U		0.059	1.2	0.25	U		0.012	0.25	0.25	U		0.012	0.25
Nitroglycerin	6.2	0.61	na	0.5	U		0.015	0.5	2.5	U		0.075	2.5	2.4	U		0.073	2.4	0.5	U		0.015	0.5	0.5	U		0.015	0.5
Metals (mg/kg)																												
Antimony	41	3.1	na	0.69	U	UL	0.23	0.69	0.81	J	L	0.36	1.1	0.92	J	L	0.34	1	1.3	U	UL	0.42	1.3	0.71	U	UL	0.24	0.71
Arsenic	1.6	0.39	15.8	3		L	0.17	0.58	3.4		L	0.27	0.9	3.7		L	0.25	0.85	14		L	0.32	1.1	2.8		L	0.18	0.59
Barium	19000	1500	209	62.5		K	0.12	0.35	78.7		K	0.18	0.54	57		K	0.17	0.51	76.8		K	0.21	0.63	70.2		K	0.12	0.35
Beryllium	200	16	1.02	0.68			0.012	0.12	0.74			0.018	0.18	0.64			0.017	0.17	0.48			0.021	0.21	0.51			0.012	0.12
Cadmium	80	7	0.69	0.3			0.058	0.17	0.57			0.09	0.27	0.59			0.085	0.25	0.56			0.11	0.32	0.18			0.059	0.18
Chromium	150000	12000	65.3	21.5		L	0.23	0.69	**68.3**		**L**	0.36	1.1	**75.7**		**L**	0.34	1	19.4		L	0.42	1.3	23.7		L	0.24	0.71
Cobalt	30	2.3	72.3	21			0.12	0.35	5.4			0.18	0.54	4.7			0.17	0.51	6.6			0.21	0.63	5.7			0.12	0.35
Copper	4100	310	53.5	14	B	J	0.17	0.58	**83.5**	**B**	**J**	0.27	0.9	**100**	**B**	**J**	0.25	0.85	18		J	0.32	1.1	7.6		J	0.18	0.59
Lead	800	400	26.8	18.2	B	K	0.069	0.23	**257**	**B**	**K**	0.11	0.36	**305**	**B**	**K**	0.1	0.34	**51.3**	**B**	**K**	0.13	0.42	16.7	B	K	0.071	0.24
Manganese	2300	180	2543	944			0.29	0.92	237			0.45	1.4	202			0.42	1.4	510			0.53	1.7	504			0.29	0.94
Mercury	4.3	1.0	0.13	**0.16**			0.009	0.046	**0.21**			0.015	0.072	**0.24**			0.015	0.068	**0.43**			0.018	0.084	0.086			0.01	0.047
Nickel	2000	150	62.8	15.4		J	0.12	0.35	55.4		J	0.18	0.54	59.6		J	0.17	0.51	13.2		J	0.21	0.63	9.9		J	0.12	0.35
Selenium	510	39	na	0.49		L	0.12	0.35	0.74		L	0.18	0.54	0.73		L	0.17	0.51	1.2		L	0.21	0.63	0.66		L	0.12	0.35
Silver	510	39	na	0.093	J	J	0.035	0.12	0.27			0.054	0.18	0.19			0.051	0.17	0.073	J	J	0.063	0.21	0.043	J	J	0.035	0.12
Thallium	1	0.78	2.11	0.26			0.058	0.17	0.27	U		0.09	0.27	0.25	U		0.085	0.25	0.55			0.11	0.32	0.15	J	J	0.059	0.18
Vanadium	520	39	108	74.4		J	0.69	2.3	19.2		J	1.1	3.6	15.9		J	1	3.4	33.9		J	1.3	4.2	47.8		J	0.71	2.4
Zinc	31000	2300	202	40.9		J	0.69	2.3	66.7		J	1.1	3.6	60.6		J	1	3.4	21.7		J	1.3	4.2	33.1		J	0.71	2.4

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 3-3
SWMU 48 Supplemental Data Investigation Soil Sample Results - 2010
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Analyte			Sample ID	48TP17					48TP18					48TP20					48TP21					48TP22				
			Sample Date	3/18/10					3/18/10					3/18/10					3/18/10					3/18/10				
			Sample Depth	4-5					6-7					1-2					3-4					5-6				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Explosives (mg/kg)																												
1,3,5-Trinitrobenzene	2700	220	na	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*
1,3-Dinitrobenzene	6.2	0.61	na	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*	0.25	U		*0.004*	*0.25*
2,4,6-Trinitrotoluene	79	19	na	0.25	U		*0.019*	*0.25*	0.25	U		*0.019*	*0.25*	0.25	U		*0.019*	*0.25*	0.25	U		*0.019*	*0.25*	0.25	U		*0.019*	*0.25*
2,4-Dinitrotoluene	5.5	1.6	na	0.078	J	J	*0.005*	*0.25*	0.15	J	J	*0.005*	*0.25*	0.25	U		*0.005*	*0.25*	0.25	U		*0.005*	*0.25*	0.25	U		*0.005*	*0.25*
2,6-Dinitrotoluene	62	6.1	na	0.04	J	J	*0.007*	*0.25*	0.16	J PG	J	*0.007*	*0.25*	0.25	U		*0.007*	*0.25*	0.25	U		*0.007*	*0.25*	0.25	U		*0.007*	*0.25*
2-amino-4,6-Dinitrotoluene	200	15	na	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*
4-amino-2,6-Dinitrotoluene	190	15	na	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*	0.25	U		*0.009*	*0.25*
HMX	4900	380	na	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*	0.25	U		*0.012*	*0.25*
Nitroglycerin	6.2	0.61	na	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*	0.5	U		*0.015*	*0.5*
Metals (mg/kg)																												
Antimony	41	3.1	na	0.71	U	UL	*0.24*	*0.71*	0.75	U	UL	*0.25*	*0.75*	0.74	U	UL	*0.25*	*0.74*	0.79	U	UL	*0.26*	*0.79*	0.76	U	UL	*0.25*	*0.76*
Arsenic	1.6	0.39	15.8	2.8		L	*0.18*	*0.59*	1.8		L	*0.19*	*0.62*	4.1		L	*0.19*	*0.62*	4.1		L	*0.2*	*0.66*	2.3		L	*0.19*	*0.63*
Barium	19000	1500	209	110		K	*0.12*	*0.35*	47.1		K	*0.12*	*0.37*	63.9		K	*0.12*	*0.37*	53.8		K	*0.13*	*0.4*	46.2		K	*0.13*	*0.38*
Beryllium	200	16	1.02	0.61			*0.012*	*0.12*	0.54			*0.012*	*0.12*	0.41			*0.012*	*0.12*	0.5			*0.013*	*0.13*	0.55			*0.013*	*0.13*
Cadmium	80	7	0.69	0.16	J	J	*0.059*	*0.18*	0.21			*0.062*	*0.19*	0.3			*0.062*	*0.19*	0.26			*0.066*	*0.2*	0.24			*0.063*	*0.19*
Chromium	150000	12000	65.3	18.9		L	*0.24*	*0.71*	17.9		L	*0.25*	*0.75*	28.6		L	*0.25*	*0.74*	35		L	*0.26*	*0.79*	20.4		L	*0.25*	*0.76*
Cobalt	30	2.3	72.3	6.4			*0.12*	*0.35*	4.4			*0.12*	*0.37*	18.9			*0.12*	*0.37*	4.5			*0.13*	*0.4*	9.6			*0.13*	*0.38*
Copper	4100	310	53.5	8.8		J	*0.18*	*0.59*	12.9		J	*0.19*	*0.62*	11.4		J	*0.19*	*0.62*	13.8	B	J	*0.2*	*0.66*	15.3	B	J	*0.19*	*0.63*
Lead	800	400	26.8	22.8	B	K	*0.071*	*0.24*	14.1	B	K	*0.075*	*0.25*	**34.5**	**B**	**K**	*0.074*	*0.25*	14.7	B	K	*0.079*	*0.26*	20	B	K	*0.076*	*0.25*
Manganese	2300	180	2543	1250	RLA		*2.9*	*9.4*	167			*0.31*	*1*	689			*0.31*	*0.99*	124			*0.33*	*1.1*	280			*0.32*	*1*
Mercury	4.3	1.0	0.13	0.071			*0.01*	*0.047*	0.052			*0.011*	*0.05*	**0.36**			*0.011*	*0.05*	**0.24**			*0.011*	*0.053*	0.096			*0.011*	*0.051*
Nickel	2000	150	62.8	8.4		J	*0.12*	*0.35*	11.6		J	*0.12*	*0.37*	10.3		J	*0.12*	*0.37*	13.3		J	*0.13*	*0.4*	12.6		J	*0.13*	*0.38*
Selenium	510	39	na	0.89		L	*0.12*	*0.35*	0.47		L	*0.12*	*0.37*	0.7		L	*0.12*	*0.37*	0.79		L	*0.13*	*0.4*	0.52		L	*0.13*	*0.38*
Silver	510	39	na	0.037	J	J	*0.035*	*0.12*	0.068	J	J	*0.037*	*0.12*	0.09	J	J	*0.037*	*0.12*	0.07	J	J	*0.04*	*0.13*	0.063	J	J	*0.038*	*0.13*
Thallium	1	0.78	2.11	0.13	J	J	*0.059*	*0.18*	0.14	J	J	*0.062*	*0.19*	0.57			*0.062*	*0.19*	0.3			*0.066*	*0.2*	0.2			*0.063*	*0.19*
Vanadium	520	39	108	28.8		J	*0.71*	*2.4*	62		J	*0.75*	*2.5*	65.9		J	*0.74*	*2.5*	85.9		J	*0.79*	*2.6*	67		J	*0.76*	*2.5*
Zinc	31000	2300	202	26.8		J	*0.71*	*2.4*	33		J	*0.75*	*2.5*	38.8		J	*0.74*	*2.5*	41.4		J	*0.79*	*2.6*	35.8		J	*0.76*	*2.5*

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 3-3
Legend

12	J	Shading and black font indicate an industrial SL exceedance.
12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
NA = not applicable.

Lab Q = Lab Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
G = Elevated reporting limit. The reporting limit is elevated due to matrix interference.
J (organics) = Value <MRL and >MDL and is considered estimated.
J (metals) = Estimated result. Result is less than RL.
PG = The percent difference between the original and confirmation analyses is greater than 40%.
RLA = The reporting limit for this analyte is elevated due to sample dilution.
U = Analyte not-detected at the method reporting limit.
V = Elevated reporting limit. The reporting limit is elevated due to limited sample volume.

Val Q = Validation Data Qualifiers
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 3-4
Summary of SWMU 48 Supplemental Data Investigation Soil Sample Results - 2010

Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (mg/kg)											
1,3,5-Trinitrobenzene	2700	220	na	0	0	na	3	20	0.13	0.62	48TP08
1,3-Dinitrobenzene	6.2	0.61	na	0	0	na	1	20	0.073	0.073	48TP15
2,4,6-Trinitrotoluene	79	19	na	0	0	na	4	20	0.056	1.6	48TP08
2,4-Dinitrotoluene	5.5	1.6	na	1	3	na	10	20	0.022	6.9	48TP14
2,6-Dinitrotoluene	62	6.1	na	0	0	na	12	20	0.013	2.8	48TP14D
2-amino-4,6-Dinitrotoluene	200	15	na	0	0	na	3	20	0.032	2.6	48TP08D
4-amino-2,6-Dinitrotoluene	190	15	na	0	0	na	6	20	0.01	0.45	48TP08D
HMX	4900	380	na	0	0	na	1	20	0.025	0.025	48TP04-RFI
Nitroglycerin	6.2	0.61	na	0	1	na	3	20	0.051	1.2	48TP04-RFI
Metals (mg/kg)											
Antimony	41	3.1	na	0	1	na	8	20	0.36	3.2	48TP04-RFI
Arsenic	1.6	0.39	15.8	1	1	1	19	20	1.8	112	48TP08
Barium	19000	1500	209	0	0	0	20	20	0.96	199	48TP04-RFI
Beryllium	200	16	1.02	0	0	0	19	20	0.41	0.91	48TP05
Cadmium	80	7	0.69	0	1	7	20	20	0.16	9.2	48TP02-RFI
Chromium	150000	12000	65.3	0	0	2	20	20	2.7	75.7	48TP14D
Cobalt	30	2.3	72.3	0	0	0	20	20	4.4	21	48TP13
Copper	4100	310	53.5	1	1	6	20	20	5.1	81800	48TP02-RFI
Lead	800	400	26.8	1	3	11	20	20	14.1	114000	48TP02-RFI
Manganese	2300	180	2543	0	0	0	20	20	11.3	1250	48TP17
Mercury	4.3	1.0	0.13	3	5	14	20	20	0.024	25.5	48TP04-RFI
Nickel	2000	150	62.8	0	0	0	20	20	5.3	59.6	48TP14D
Selenium	510	39	na	0	0	na	20	20	0.47	1.2	48TP07
Silver	510	39	na	0	0	na	20	20	0.037	30	48TP04-RFI
Thallium	1	0.78	2.11	0	0	0	14	20	0.11	1.3	48TP08
Vanadium	520	39	108	0	0	0	19	20	15.2	85.9	48TP21
Zinc	31000	2300	202	0	0	2	19	20	20.1	499	48TP04-RFI

Table 3-5
SWMU 48 Supplemental Data Investigation TCLP Results - 2010

Analyte	TCLP RL	Sample ID		
		48TP06	**48TP10**	**48TP19**
TCLP SVOCs (ug/L)				
TCLP 2,4-Dinitrotoluene	130	< 0.05	< 0.05	< 0.05
TCLP Hexachlorobenzene	130	< 0.05	< 0.05	< 0.05
TCLP Hexachlorobutadiene	500	< 0.05	< 0.05	< 0.05
TCLP Hexachloroethane	3000	< 0.05	< 0.05	< 0.05
TCLP 2-Methylphenol	200000	< 0.05	< 0.05	< 0.05
TCLP Nitrobenzene	2000	< 0.05	< 0.05	< 0.05
TCLP Pentachlorophenol	100000	< 0.25	< 0.25	< 0.25
TCLP Pyridine	5000	< 0.1	< 0.1	< 0.1
TCLP 2,4,5-Trichlorophenol	400000	< 0.05	< 0.05	< 0.05
TCLP 2,4,6-Trichlorophenol	2000	< 0.05	< 0.05	< 0.05
TCLP 3-Methylphenol & 4-Methylphenol	200000	< 0.05	< 0.05	< 0.05
TCLP 1,4-Dichlorobenzene	7500000	< 0.05	< 0.05	< 0.05
TCLP Metals (mg/L)				
TCLP Arsenic	5	< 1.0	< 1.0	< 1.0
TCLP Lead	5	< 0.5	**0.018**	< 0.5
TCLP Barium	100	**0.35**	**0.70**	**1.1**
TCLP Mercury	0.2	**0.0020**	**0.0015**	**0.0020**
TCLP Selenium	1	< 0.20	< 0.20	< 0.20
TCLP Silver	5	< 0.10	< 0.10	< 0.10
TCLP Chromium	5	< 0.10	< 0.10	< 0.10
TCLP Cadmium	1	< 0.050	< 0.050	< 0.050
Misc				
pH (pH units)	<2 or >12	**12.4**	**10.3**	**8.7**
Cyanide, Total (mg/kg)	na	**0.70**	**0.69**	**0.63**

Notes: Detections are shown in bold.

Shaded cells indicate a value greater than the TCLP Regulatory Limit (RL).

3.3 SWMU 48 Interim Measures, Shaw, 2011

Based upon the 2010 Supplemental Data Investigation, an interim measures remedial action was performed to address SWMU 48 soil. In accordance with the *SWMU 48 Interim Measures Work Plan* (Shaw, 2011), the interim measures were conducted to mitigate the threat of a contaminant release, migration, and/or exposure to the public and the environment, as well as facilitate clean closeout in accordance with Part II(D)(11-21) interim measure of the *RFAAP Corrective Action Permit* (USEPA, 2000a).

Preliminary remedial goals (PRGs) for soil at SWMU 48 were established in Shaw (2011) and were obtained from USEPA's Office of Solid Waste and Emergency Response (OSWER) Directives, where available. For analytes for which published cleanup levels were not identified, PRGs were calculated such that risks to human health are within the acceptable range. The published or calculated values were then compared with the background values [95% upper tolerance limit (UTL)], and the maximum of the two values was selected as the remedial goal (RG) for the analyte. Future land use for the SWMU 48 study area is industrial and the chosen RGs for the site are also industrial, unless background levels were higher. **Table 3-6** summarizes the selected RGs for the contaminants of interest (COIs) in soil at SWMU 48.

Table 3-6
COIs and Remedial Goals Identified

Chemical	i-RG (mg/kg)
Antimony	410
Arsenic	15.8*
Cadmium	800
Copper	41,000
Lead	800
Mercury	43

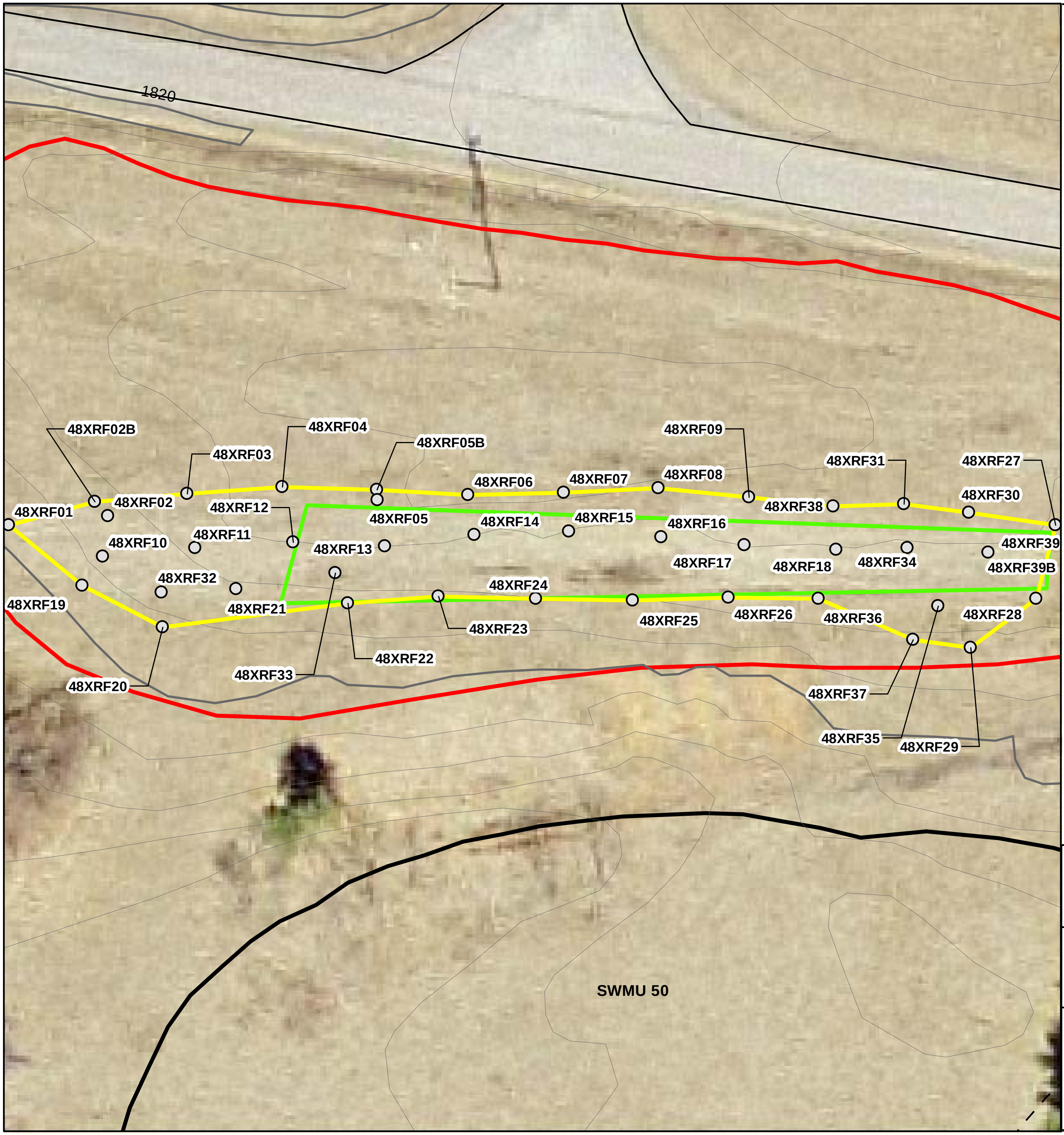
RGs based on published USEPA values (2011).

Prior to the commencement of interim measures activities at SWMU 48, the test pit boundaries established during the 2010 Supplemental Data Investigation were re-established using a Global Positioning System (GPS) and visual observation of subsidence. As detailed in the *SWMU 48 Interim Measures Completion Report* (Shaw, 2012), a total of 3,392.99 tons (2,423 cubic yards) of non-hazardous and 101.61 tons (73 cubic yards) of hazardous material were removed from the southern trench at SWMU 48. A total of 39 x-ray fluorescence (XRF) confirmation samples were collected from the excavation bottom and sidewalls to confirm that all contaminated soils had been removed to or below the industrial RGs selected for arsenic, antimony, cadmium, copper, lead, and mercury. The results from the XRF screening samples are presented in **Table 3-7**. Ten percent of the XRF confirmation samples (5 total) were sent to an off-site laboratory for the analysis of TAL metals and explosives analysis. The XRF and laboratory confirmation sample locations are displayed on **Figures 3-6 and 3-7**, respectively. Laboratory confirmation sample results are discussed in *Section 4.2*.

Table 3-7
SWMU 48 XRF Soil Delineation Results

XRF Sample ID	Sample Depth (ft bgs)	Sb	As	Cd	Cu	Pb	Hg
48xrf01	8	<LOD	<LOD	<LOD	<LOD	20	<LOD
48xrf02	8	<LOD	15.5	<LOD	<LOD	15	<LOD
48xrf02b	8	<LOD	<LOD	<LOD	<LOD	22	<LOD
48xrf03	7	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf04	7	<LOD	<LOD	<LOD	<LOD	15	<LOD
48xrf05	8	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf05b	8	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf06	8	<LOD	<LOD	<LOD	<LOD	14	<LOD
48xrf07	8	<LOD	13	<LOD	36.5	16	<LOD
48xrf08	8	<LOD	<LOD	<LOD	31.5	14	<LOD
48xrf09	8	<LOD	<LOD	<LOD	<LOD	20	<LOD
48xrf10	16	<LOD	<LOD	<LOD	<LOD	12	<LOD
48xrf11	16	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf12	16	<LOD	<LOD	<LOD	<LOD	18	<LOD
48xrf13	17	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf14	16	<LOD	<LOD	<LOD	<LOD	14	<LOD
48xrf15	17	<LOD	<LOD	<LOD	<LOD	24	<LOD
48xrf16	17	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf17	17	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf18	17	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf19	8	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf20	7	<LOD	<LOD	<LOD	<LOD	17	<LOD
48xrf21	17	<LOD	<LOD	<LOD	<LOD	16	<LOD
48xrf22	8	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf23	8	<LOD	<LOD	<LOD	<LOD	20	<LOD
48xrf24	8	<LOD	<LOD	<LOD	<LOD	17	<LOD
48xrf25	8	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf26	8	<LOD	<LOD	<LOD	<LOD	23	<LOD
48xrf27	8	<LOD	<LOD	<LOD	<LOD	16	<LOD
48xrf28	9	<LOD	<LOD	<LOD	<LOD	17	<LOD
48xrf29	8	<LOD	<LOD	<LOD	<LOD	18	<LOD
48xrf30	8	<LOD	<LOD	<LOD	<LOD	14	<LOD
48xrf31	8	<LOD	<LOD	<LOD	<LOD	17	<LOD
48xrf32	16	<LOD	<LOD	<LOD	<LOD	17	<LOD
48xrf33	16	<LOD	<LOD	<LOD	<LOD	13	<LOD
48xrf34	17	<LOD	<LOD	<LOD	<LOD	16	<LOD
48xrf35	17	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
48xrf36	8	<LOD	<LOD	<LOD	<LOD	22	<LOD
48xrf37	8	<LOD	<LOD	<LOD	<LOD	14	<LOD
48xrf38	8	<LOD	<LOD	<LOD	<LOD	15	<LOD
48xrf39	16	<LOD	<LOD	<LOD	285	408	<LOD
48xrf39b	17	<LOD	<LOD	<LOD	<LOD	13	<LOD

<LOD = Below the limit of detection.



ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-6_SWMU48_PostEx_XRF_Sample_Locations.mxd

LEGEND

- ○ Soil XRF Sample Location
- 🟨 Excavated Area
- 🟩 Southern Trench Boundary (GPS)
- — 10 ft Contour Line
- — 2 ft Contour Line
- – – – Dirt Road
- — Paved Road
- 🟥 SWMU 48 Boundary
- ⬛ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:
0 20 40 80
Feet

U.S. Army Corps of Engineers

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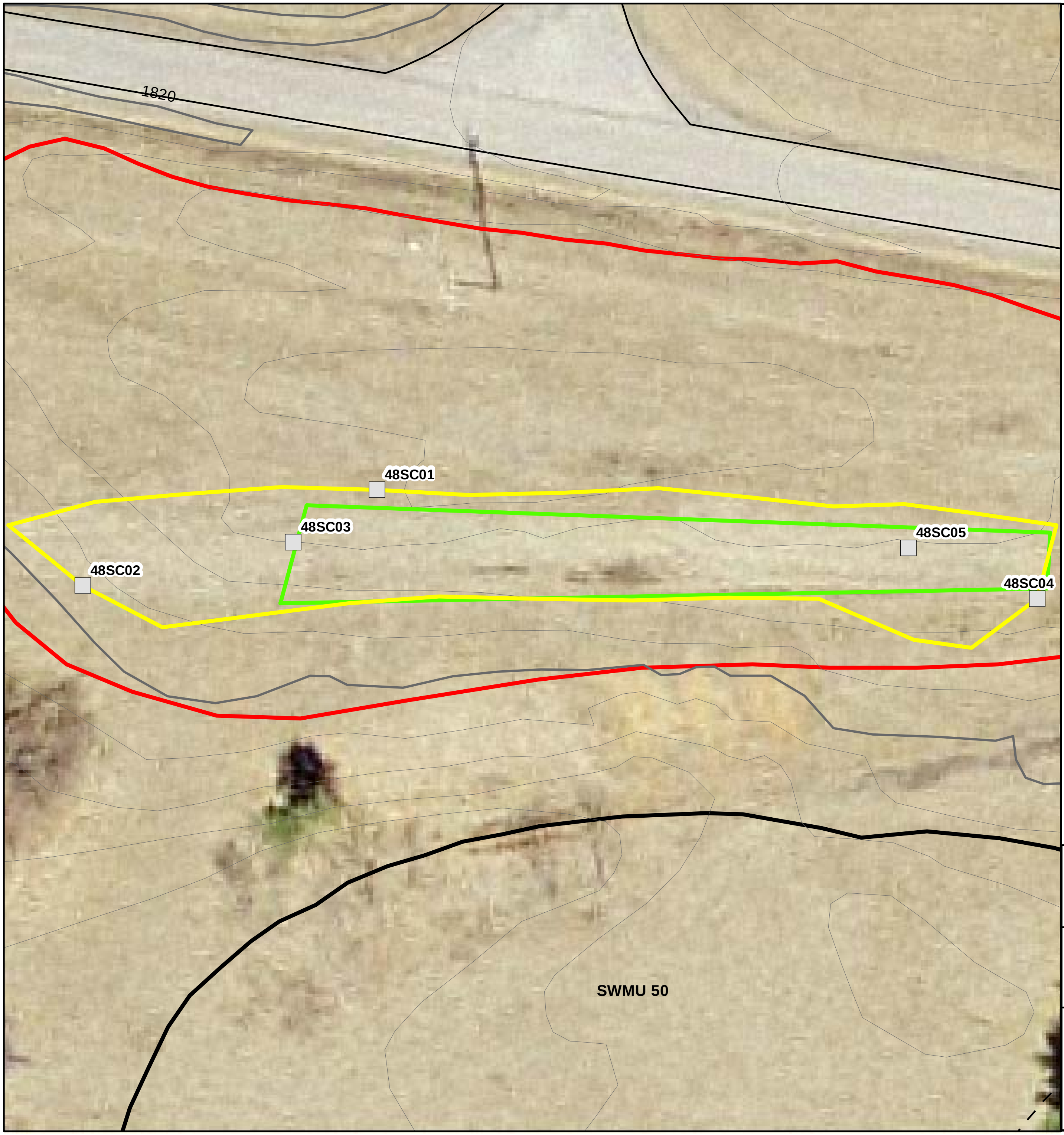
Belcamp, Maryland 21017

FIGURE 3-6
SWMU 48
Post-Excavation XRF Sample Locations
Radford Army Ammunition Plant,
Radford, VA



LEGEND

◻ Soil Lab Confirmation Sample Location
🟨 Excavated Area
🟩 Southern Trench Boundary (GPS)
— 10 ft Contour Line
— 2 ft Contour Line
- - - Dirt Road
— Paved Road
🟥 SWMU 48 Boundary
□ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

N

Scale:
0 20 40 80
Feet

U.S. Army Corps of Engineers

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Belcamp, Maryland 21017

FIGURE 3-7
SWMU 48 Post-Excavation
Confirmation Soil Sample Locations
Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig3-7_SWMU48_PostEx_Conf_Sample_Locations.mxd

Upon completion of the interim measures, the excavated area was backfilled with clean soil obtained from an off-site source, and the disturbed area was re-graded for proper drainage. After the completion of grading activities, a layer of topsoil was added and the entire area was re-seeded with straw mats.

3.4 SWMU 48/49 Supplemental RFI, Shaw, 2013

Based on data gaps identified following the 2007 RFI groundwater sampling event, additional investigation activities were performed in April 2013 to further define the extent of chlorinated solvents in groundwater. Additional investigation activities included the installation and sampling of four additional monitoring wells (49MW02, 49MW03, 49MW04, and 49MW05) to the south and east of SWMUs 48 and 49 and the sampling of 10 existing vicinity wells (48MW1, 48MW2, 48MW3, 48MW06, 49MW01, 50MW02, 13MW2, 13MW3, 13MW4, and 13MW5). The locations of the four newly-installed wells and the 10 existing well locations are illustrated on **Figure 3-8**. All 14 samples were analyzed for TCL VOCs, TAL metals (total and dissolved), and monitored natural attenuation (MNA) parameters, including methane, ethane, ethene, chloride, nitrate, sulfate, and TOC. In addition, sample 50MW02 and duplicate sample 49TM02 were analyzed for dioxins/furans. Results from the investigation are discussed in *Section 4.3*.

Boring logs and well construction diagrams for the existing and newly-installed wells are presented in **Appendix B-1**. The well purge/field water quality measurement forms for the 2013 sampling event are included in **Appendix B-3**.

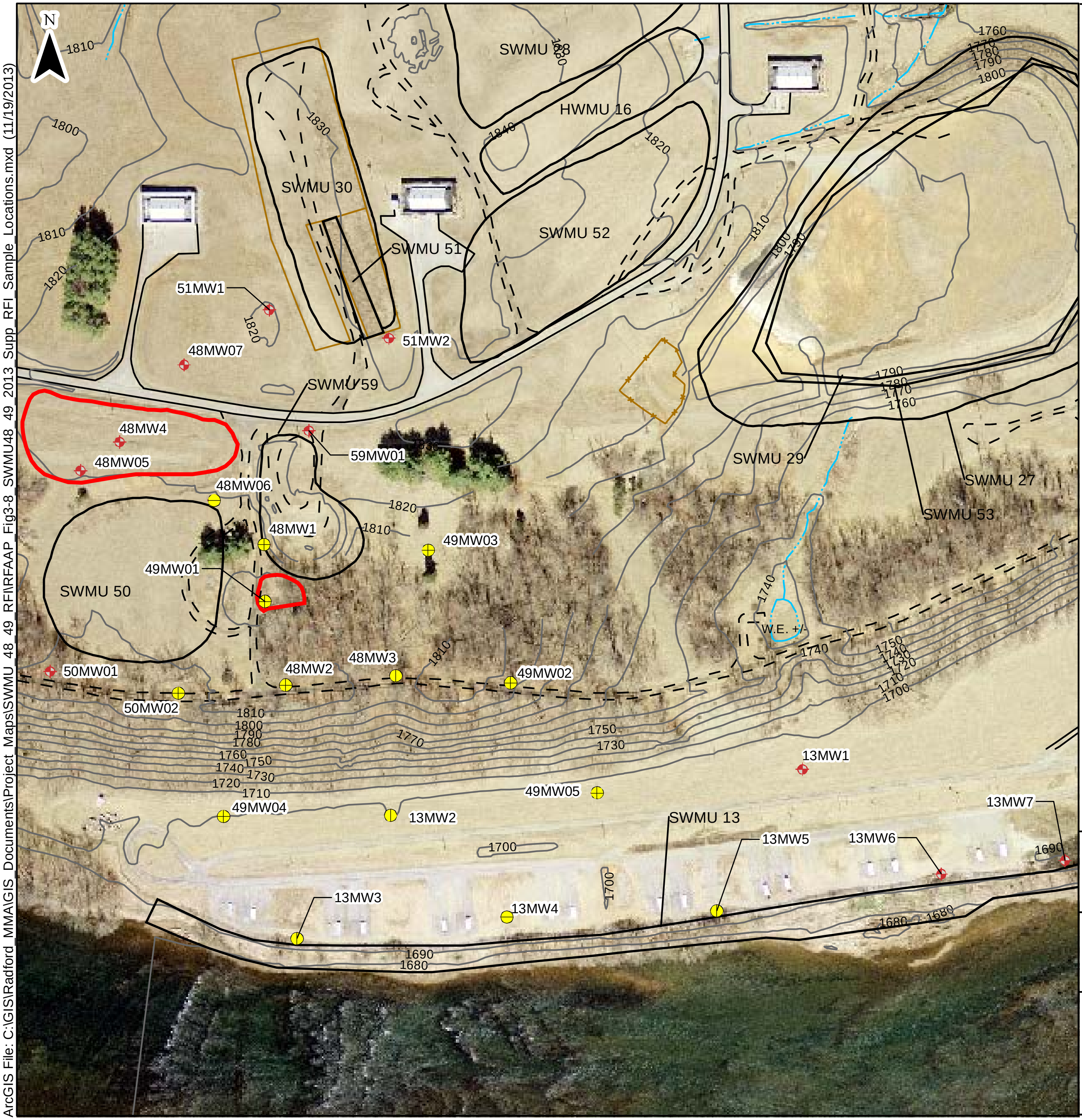
3.4.1 Survey Activities

The location coordinates and elevations were obtained for the four new wells (49MW02, 49MW03, 49MW04, and 49MW05) by Anderson and Associates, LLC of Blacksburg, VA. Horizontal control was tied to the North American Datum of 1983 in survey feet. The vertical control was tied to the National Vertical Datum of 1988. Elevations for the natural ground surface were surveyed to within ± 0.1 ft. Location coordinates were surveyed to within ± 1.0 ft.

Surveying accuracy was verified by loop closure and documented. Closure for the horizontal survey was less than 1.0 ft. The level loop for the survey was within 0.1 ft. Position information will be entered into the Environmental Restoration Information System database. Well survey coordinates and elevations are presented in **Appendix C-2**.

3.4.2 Quality Assurance

Consistent with the 2007 RFI data, the accuracy and integrity of 2013 Supplemental RFI data were ensured through the implementation of internal QC measures in accordance with *MWP Addendum 019* (Shaw, 2007), as approved by USEPA Region III and the VDEQ. QA and QC activities, including field QC, laboratory QC, data management, and data validation were integrated into the investigation program to meet DQOs established for the RFI. The 2013 Supplemental RFI data were evaluated and determined to be useable. Qualified data did not impact the data quality of the RFI. Chemical data validation reports and analytical data are provided in **Appendix A-4**.



LEGEND

- ● Monitoring Well Sampled in 2013
- ⊕ Monitoring Well
- 🟥 SWMU 48 and 49 Boundaries
- ☐ Other SWMU Boundary
- — 10 ft Contour Line
- - - Dirt Road
- — Paved Road
- — Fence

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.

Scale:
0 125 250 500 Feet

U.S. Army Corps of Engineers

Shaw Environmental, Inc.
(A CB&I Company)
4696 Millennium Drive, Suite 320
Belcamp, Maryland 21017

FIGURE 3-8

2013 Supplemental RFI Sample Locations

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford MMA\GIS Documents\Project Maps\SWMU 48 49 RFI\RFAAP Fig3-8 SWMU48 49 2013 Supp RFI Sample Locations.mxd (11/19/2013)

4.0 NATURE AND EXTENT OF CONTAMINATION

The following sections provide a discussion of the site conditions and the nature and extent of chemicals found in site media at SWMUs 48 and 49. The 2007 RFI sampling locations are illustrated on **Figure 3-1**. A summary of the results from the samples are portrayed on **Figures 3-2, 3-3, and 3-4**. The SWMU 48 post-excavation confirmation soil sample locations are illustrated on **Figure 3-7**. The distribution and concentrations of chemicals and parameter groups (i.e., VOCs, SVOCs, etc.) are evaluated for source locations, migration pathways, and potential hotspots.

Soil Screening. Chemical results from soil samples are compared to adjusted USEPA Regional industrial SLs (i-SLs) and residential SLs (r-SLs) (USEPA, 2011a), as well as facility-wide background inorganic concentrations (IT, 2001), and other regulatory criteria. i-SLs and r-SLs were adjusted downward to a hazard index (HI) of 0.1 for non-carcinogenic compounds to ensure that chemicals with additive effects are not prematurely eliminated during screening.

November 2011 SL values and background 95% UTLs for analytes detected in soil at SWMU 49 are presented for comparison in **Table 4-1** and summarized in **Table 4-2**. No soil samples were collected during RFI sampling at SWMU 48 in 2007; however, soil confirmation sampling results from the 2011 Interim Measures at SWMU 48 are presented for comparison in **Table 4-5** and summarized in **Table 4-6**. Analytical results for inorganic compounds in soil are indicated in the tables and figures as detections above SLs when they are above both the background value and a screening value. Eliminating detections above SLs in soil that are below the background value allows site-specific constituents to be more clearly indicated in the tables and figures.

Groundwater Screening. Groundwater sampling results are compared to the 2011 Edition of the Drinking Water Standards and Health Advisories (i.e., MCLs and secondary MCLs) (USEPA, 2011b) and adjusted tw-SLs (USEPA, 2011a). Analytes detected in the combined site area groundwater samples are presented and summarized for comparison against screening criteria in **Tables 4-3 and 4-4** for the 2007 RFI and in **Tables 4-7 and 4-8** for the 2013 Supplemental RFI.

4.1 RFI, Shaw, 2007

4.1.1 SWMU 49 Soil Analytical Results

Four surface soil samples (49SS02, 49SS03, 49SS04, and 49SS05) and three subsurface soil samples (49MW01A, 49MW01B, and 49MW01C) were collected at SWMU 49 and analyzed for TCL VOCs, SVOCs, PAHs, pesticides/PCBs, herbicides, explosives, TAL metals, and dioxins/furans. Detected results are presented in **Table 4-1** and summarized in **Table 4-2**. There were no detections above SLs in any of the SWMU 49 soil samples.

VOCs. Three VOCs [1,1-dichloroethene (DCE); acetone; and methylene chloride] were detected in SWMU 49 soil samples. 1,1-DCE and methylene chloride were detected together in sample 49MW01C. Acetone was detected alone in sample 49SS01. However, all the concentrations were well below the adjusted i-SLs and r-SLs.

PAHs. Five PAHs [1-methylnaphthalene; 2-methylnaphthalene; benzo(b)fluoranthene; chrysene; and phenanthrene] were detected in site soil samples. All five were detected in surface soil sample 49SS03 and all, except for benzo(b)fluoranthene, were also detected in surface soil sample 49SS02. However, all the concentrations were well below the adjusted i-SLs and r-SLs.

Table 4-1
Analytes Detected in SWMU 49 Soil Samples - 2007 RFI

Analyte			Sample ID	49MW01A					49MW01B					49MW01C					49SS02					49SS03					49SS04					49SS05				
			Sample Date	8/9/07					8/9/07					8/9/07					7/19/07					7/19/07					7/19/07					7/19/07				
			Sample Depth	4-6					10-12					18-20					0-0.5					0-0.5					0-0.5					0-0.5				
	i-SL	**r-SL**	**Background**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/kg)																																						
1,1-Dichloroethene	110000	24000	na	5.8	U		1.2	5.8	6.2	U		1.2	6.2	4.6	J	J	1.2	5.9	7.5	U		3	7.5	9.2	U		3.7	9.2	7	U		2.8	7	7.9	U		3.2	7.9
Acetone	63000000	6100000	na	58	U	UJ	29	58	62	U	UJ	31	62	59	U	UJ	29	59	70.7	J	J	37	75	92	U	UJ	46	92	70	U	UJ	35	70	79	U	UJ	40	79
Methylene chloride	53000	11000	na	12	U		5.8	12	12	U		6.2	12	11.2	J	J	5.9	12	15	U		7.5	15	18	U		9.2	18	14	U		7	14	16	U		7.9	16
PAHs (ug/kg)																																						
1-Methylnaphthalene	99000	22000	na	320	U		48	320	310	U		46	310	360	U		53	360	65.4	J	J	45	300	49.5	J	J	43	290	300	U		46	300	300	U		46	300
2-Methylnaphthalene	410000	31000	na	320	U		48	320	310	U		46	310	360	U		53	360	117	J	J	45	300	60.7	J	J	43	290	300	U		46	300	300	U		46	300
Benzo(b)fluoranthene	2100	150	na	64	U		16	64	62	U		15	62	71	U		18	71	60	U		15	60	21.1	J	J	14	58	61	U		15	61	61	U		15	61
Chrysene	210000	15000	na	64	U		16	64	62	U		15	62	71	U		18	71	17.1	J	J	15	60	22.9	J	J	14	58	61	U		15	61	61	U		15	61
Phenanthrene	1700000	170000	na	320	U		48	320	310	U		46	310	360	U		53	360	75.1	J	J	45	300	60.9	J	J	43	290	300	U		46	300	300	U		46	300
SVOCs (ug/kg)																																						
Di-n-butylphthalate	6200000	610000	na	400	U		100	400	390	U		97	390	440	U		110	440	123	J	J	93	370	128	J	J	91	360	380	U		95	380	380	U		95	380
Pesticides (ug/kg)	None detected																																					
PCBs (mg/kg)																																						
PCB-1254	0.74	0.022	na	0.02	U		0.01	0.02	0.027	U		0.013	0.027	0.027	U		0.013	0.027	0.037	U		0.037	0.037	0.124	J	J	0.018	0.036	0.0109	J	J	0.0093	0.019	0.0411		J	0.0096	0.019
PCB-1260	0.74	0.22	na	0.02	U		0.01	0.02	0.027	U		0.013	0.027	0.027	U		0.013	0.027	0.152			0.019	0.037	0.0732	J	J	0.018	0.036	0.019	U		0.0093	0.019	0.019	U		0.0096	0.019
Explosives (mg/kg)	None detected																																					
Herbicides (ug/kg)																																						
2,4-DB	490000	49000	na	80	U		65	80	78	U		64	78	88	U		72	88	74	U		61	74	92.1			59	72	76	U		62	76	78	U		63	78
Metals (mg/kg)																																						
Aluminum	99000	7700	40041	23000		J	2.8	12	17400		J	2.8	12	8650		J	3.1	13	10300			1.2	11	9220			1.1	10	22700			1.2	11	15500			1.3	12
Antimony	41	3.1	na	0.22	U	UL	0.22	3.5	0.22	U	UL	0.22	3.5	0.25	U	UL	0.25	3.9	0.86	J	B	0.29	3.3	0.63	J	B	0.28	3.1	1.5	J	B	0.29	3.3	0.73	J	B	0.31	3.5
Arsenic	1.6	0.39	15.8	0.99		L	0.23	0.47	1.3		L	0.23	0.46	1.7		L	0.25	0.52	6.2			0.21	0.44	8.2			0.2	0.42	2.3			0.21	0.44	3.2			0.23	0.47
Barium	19000	1500	209	39.8		J	0.29	12	51.3		J	0.29	12	26.5		J	0.32	13	80.8			0.27	11	67.7			0.26	10	57.5			0.27	11	69.8			0.29	12
Beryllium	200	16	1.02	0.61			0.059	0.29	0.65			0.058	0.29	**1.4**			0.065	0.32	0.52			0.055	0.27	0.55			0.052	0.26	0.69			0.054	0.27	0.61			0.058	0.29
Calcium	na	na	na	222	J	J	5.9	290	158	J	J	5.8	290	178	J	J	6.5	320	997			3.1	270	524			3	260	770			3.1	270	1450			3.3	290
Chromium	150000	12000	65.3	18		J	0.082	0.59	22.4		J	0.081	0.58	8.7		J	0.09	0.65	13.5			0.049	0.55	11.8			0.047	0.52	20.7			0.049	0.54	14.9			0.052	0.58
Cobalt	30	2.3	72.3	3.4		J	0.065	2.9	6.6		J	0.064	2.9	14.2		J	0.071	3.2	3.2			0.055	2.7	3.1			0.052	2.6	4			0.054	2.7	3.7			0.058	2.9
Copper	4100	310	53.5	12.3		J	0.11	1.5	9.4		J	0.11	1.4	4.8		J	0.12	1.6	17.6			0.049	1.4	14.4			0.047	1.3	15.9			0.049	1.4	12.8			0.052	1.5
Iron	72000	5500	50962	29300		J	0.82	5.9	17800		J	0.81	5.8	26900		J	0.9	6.5	13800			0.66	5.5	13800			0.63	5.2	26900			0.65	5.4	17900			0.7	5.8
Lead	800	400	26.8	7.9		J	0.14	5.9	4.9	J	J	0.14	5.8	0.16	U	UJ	0.16	6.5	**71.6**			0.11	5.5	**50.3**			0.1	5.2	13.4		K	0.11	5.4	20.5		K	0.12	5.8
Magnesium	na	na	na	1090		J	5.9	290	797		J	5.8	290	451		J	6.5	320	706			0.4	270	518			0.39	260	1120			0.4	270	863			0.43	290
Manganese	2300	180	2543	102		J	0.059	0.88	322		J	0.29	4.3	803		J	0.32	4.8	299			0.16	4.1	293			0.16	3.9	165			0.033	0.82	358			0.17	4.4
Mercury	4.3	1.0	0.13	0.046	J	J	0.012	0.097	0.034	J	J	0.01	0.081	0.012	U		0.012	0.099	**0.17**		**L**	0.007	0.089	**0.31**			0.006	0.086	0.058	J	B	0.007	0.092	0.072	J	B	0.007	0.087
Nickel	2000	150	62.8	9.6		J	0.15	2.4	8.8		J	0.14	2.3	11.2		J	0.16	2.6	5.8			0.055	2.2	5.9			0.052	2.1	9.6			0.054	2.2	7.4			0.058	2.3
Potassium	na	na	na	1260		J	5.9	590	882		J	5.8	580	745		J	6.5	650	597		B	5.5	550	538		B	5.2	520	1060			5.4	540	776		B	5.8	580
Selenium	510	39	na	0.94	J	L	0.26	5.9	0.72	J	L	0.26	5.8	1.2	J	L	0.29	6.5	5.2	J	K	0.11	5.5	5.4		K	0.1	5.2	9.4		K	0.11	5.4	6.4		K	0.12	5.8
Sodium	na	na	na	460	J	B	29	590	288	J	B	29	580	238	J	B	32	650	78.4	J	B	45	550	73.4	J	B	43	520	45	U		45	540	48	U		48	580
Thallium	1	0.78	2.11	1.6	J	J	1.3	2.4	1.3	U		1.3	2.3	1.6	J	J	1.4	2.6	5.2	U	UL	5.2	11	4.8	U	UL	4.8	10	13	U	UL	13	22	5.2	U	UL	5.2	12
Vanadium	520	39	108	64.7		J	0.059	2.9	30.1		J	0.058	2.9	18.5		J	0.065	3.2	25.6			0.033	2.7	24.3			0.031	2.6	56.3			0.033	2.7	37.7			0.035	2.9
Zinc	31000	2300	202	29.6		J	0.29	1.2	24.6		J	0.29	1.2	10.7		J	0.32	1.3	56.5			0.071	1.1	45.8			0.068	1	49.1			0.071	1.1	44.5			0.076	1.2
Dioxins/Furans (ng/kg)																																						
2,3,7,8-TCDF	na	na	na	0.317	A	J	NA	NA	0.279	A	J	NA	NA	0.334	A	J	NA	NA	1.19					1.44					0.413	A	B			0.938	A	J		
2,3,7,8-TCDD	18	4.5	na	0.392	U		0.392	0.392	0.317	U		0.317	0.317	0.26	U		0.26	0.26	0.198	A, EMPC	J	0.16	0.16	0.318	A	J			0.198	U		0.198	0.198	0.333	A, EMPC	J	0.161	0.161
1,2,3,7,8-PECDD	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	3.72	A	J			1.91	A	J			0.553	U		0.553	0.553	2.89	A	J		
1,2,3,4,7,8-HXCDD	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	8.98					4.29	A	J			0.588	A	J			9				
1,2,3,6,7,8-HXCDD	na	na	na	0.579	U		0.579	0.579	0.286	A	J	0.517	0.517	0.553	U		0.553	0.553	29.3					13.6					1.6	A	J			36.5				
1,2,3,7,8,9-HXCDD	na	na	na	0.579	U		0.579	0.579	0.272	A	J	0.517	0.517	0.553	U		0.553	0.553	22.2					11.7					1.32	A	J			21				
1,2,3,4,6,7,8-HPCDD	na	na	na	13.3			NA	NA	11.8			NA	NA	3.37	A	J	NA	NA	1110					549					80					946				
OCDD	na	na	na	2010			NA	NA	773			NA	NA	295			NA	NA	10000	E	J			6510	E	J			4540	E	J			9640	E	J		
1,2,3,7,8-PECDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	1.45	A	J			1.8	A	J			0.168	A	J			0.567	A	J		
2,3,4,7,8-PECDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	0.348	A	J			0.189	A, EMPC	J	0.537	0.537	0.252	A, EMPC	B	0.553	0.553	1.04	A	J		
1,2,3,4,7,8-HXCDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	8.47					5.21	A	J			0.791	A	J			4.61	A	J		
1,2,3,6,7,8-HXCDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	6.38					3.66	A	J			0.343	A	J			3.71	A	J		
2,3,4,6,7,8-HXCDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	8.25					4.48	A	J			0.422	A	J			6				
1,2,3,7,8,9-HXCDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	1.3	A	J			0.833	A	J			0.553	U		0.553	0.553	0.839	A	J		
1,2,3,4,6,7,8-HPCDF	na	na	na	1	A	B	NA	NA	1.4	A	B	NA	NA	0.883	A	B	NA	NA	214					101					10.4					138				
1,2,3,4,7,8,9-HPCDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	13.7					7.64					0.718	A	J			10.2				
OCDF	na	na	na	1.9	A	B	NA	NA	3.6	A	B	NA	NA	2	A	B	NA	NA	736					389					30.2					367				
TOTAL TCDD	na	na	na	0.392	U		0.392	0.392	0.317	U		0.317	0.317	0.26	U		0.26	0.26	5.67	A, EMPC	J			18.6	A, EMPC	J			1.2	A, EMPC	J	0.198	0.198	4.08	A, EMPC	J		
TOTAL PECDD	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	14.4					10.3					1.13					13.2	A, EMPC	J		
TOTAL HXCDD	na	na	na	1.06			NA	NA	1.56			NA	NA	0.553	U		0.553	0.553	148	A, EMPC	J			77.8	A, EMPC	J			11.1	A, EMPC	J			137				
TOTAL HPCDD	na	na	na	28.1			NA	NA	20.8			NA	NA	5.79			NA	NA	1670					871					147					1400				
TOTAL TCDF	na	na	na	0.584			NA	NA	0.391			NA	NA	0.71			NA	NA	15.6	A, EMPC	J			17.8	A, EMPC	J			1.59	A, EMPC	J			8.68	A, EMPC	J		
TOTAL PECDF	na	na	na	0.579	U		0.579	0.579	0.517	U		0.517	0.517	0.553	U		0.553	0.553	46.3	A, EMPC	J			30	A, EMPC	J			2.94	A, EMPC	J			25.3	A, EMPC	J		
TOTAL HXCDF	na	na	na	0.229			NA	NA	0.702			NA	NA	0.228			NA	NA	221					101					8.87					138				
TOTAL HPCDF	na	na	na	1.57			NA	NA	3.28			NA	NA	1.58			NA	NA	719					325					28.9					418				

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-1
Legend

12	J	Bold outline indicates a residential SL exceedance.
12	**J**	Bold, underlined font indicates a background exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

SLs for carcinogenic compounds are shown in red font.
SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
The pyrene SLs were used for acenaphthylene, benzo(g,h,i)perylene and phenanthrene and are shown in blue font.
Inorganic results below background UTLs are not indicated as exceedances on the table.
SL Source: ORNL Regional Screening Table. November 2011.
Lead screening values from Technical Review Workgroup for Lead: Guidance Document (USEPA, 2003b).
mg/kg = milligrams per kilogram (parts per million).
ng/kg = nanograms per kilogram (parts per trillion).
μg/kg = micrograms per kilogram (parts per billion).
NA = not applicable.

Lab Q = Lab Data Qualifiers
A (dioxins) = Value <MRL and >MDL and is considered estimated.
E (dioxins) = Amount detected is greater than upper calibration limit. Value is estimated.
EMPC (dioxins) = The ion-abundance ratio between the two characteristic PCDDPCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).
J = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 4-2
Summary of Analytes Detected in SWMU 49 Soil Samples - 2007 RFI

Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)											
1,1-Dichloroethene	110000	24000	na	0	0	na	1	7	4.6	4.6	49MW01C
Acetone	63000000	6100000	na	0	0	na	1	7	70.7	70.7	49SS02
Methylene chloride	53000	11000	na	0	0	na	1	7	11.2	11.2	49MW01C
PAHs (ug/kg)											
1-Methylnaphthalene	99000	22000	na	0	0	na	2	7	49.5	65.4	49SS02
2-Methylnaphthalene	410000	31000	na	0	0	na	2	7	60.7	117	49SS02
Benzo(b)fluoranthene	2100	150	na	0	0	na	1	7	21.1	21.1	49SS03
Chrysene	210000	15000	na	0	0	na	2	7	17.1	22.9	49SS03
Phenanthrene	1700000	170000	na	0	0	na	2	7	60.9	75.1	49SS02
SVOCs (ug/kg)											
Di-n-butylphthalate	6200000	610000	na	0	0	na	2	7	123	128	49SS03
Pesticides (ug/kg)	***None detected***										
PCBs (mg/kg)											
PCB-1254	0.74	0.022	na	0	2	na	3	7	0.0109	0.124	49SS03
PCB-1260	0.74	0.22	na	0	0	na	2	7	0.0732	0.152	49SS02
Explosives (mg/kg)	***None detected***										
Herbicides (ug/kg)											
2,4-DB	490000	49000	na	0	0	na	1	7	92.1	92.1	49SS03
Metals (mg/kg)											
Aluminum	99000	7700	40041	0	0	0	7	7	8650	23000	49MW01A
Antimony	41	3.1	na	0	0	na	4	7	0.63	1.5	49SS04
Arsenic	1.6	0.39	15.8	0	0	0	7	7	0.99	8.2	49SS03
Barium	19000	1500	209	0	0	0	7	7	26.5	80.8	49SS02
Beryllium	200	16	1.02	0	0	1	7	7	0.52	1.4	49MW01C
Calcium	na	na	na	na	na	na	7	7	158	1450	49SS05
Chromium	150000	12000	65.3	0	0	0	7	7	8.7	22.4	49MW01B
Cobalt	30	2.3	72.3	0	0	0	7	7	3.1	14.2	49MW01C
Copper	4100	310	53.5	0	0	0	7	7	4.8	17.6	49SS02
Iron	72000	5500	50962	0	0	0	7	7	13800	29300	49MW01A
Lead	800	400	26.8	0	0	2	6	7	4.9	71.6	49SS02
Magnesium	na	na	na	na	na	na	7	7	451	1120	49SS04
Manganese	2300	180	2543	0	0	0	7	7	102	803	49MW01C
Mercury	4.3	1.0	0.13	0	0	2	6	7	0.034	0.31	49SS03
Nickel	2000	150	62.8	0	0	0	7	7	5.8	11.2	49MW01C
Potassium	na	na	na	na	na	na	7	7	538	1260	49MW01A
Selenium	510	39	na	0	0	na	7	7	0.72	9.4	49SS04
Sodium	na	na	na	na	na	na	5	7	73.4	460	49MW01A
Thallium	1	0.78	2.11	0	0	0	2	7	1.6	1.6	49MW01A
Vanadium	520	39	108	0	0	0	7	7	18.5	64.7	49MW01A
Zinc	31000	2300	202	0	0	0	7	7	10.7	56.5	49SS02
Dioxins/Furans (ng/kg)											
2,3,7,8-TCDF	na	na	na	na	na	na	7	7	0.279	1.44	49SS03
2,3,7,8-TCDD	19	4.3	na	0	0	na	3	7	0.198	0.333	49SS05
1,2,3,7,8-PECDD	na	na	na	na	na	na	3	7	1.91	3.72	49SS02
1,2,3,4,7,8-HXCDD	460	100	na	0	0	na	4	7	0.588	9	49SS05
1,2,3,6,7,8-HXCDD	460	100	na	0	0	na	5	7	0.286	36.5	49SS05
1,2,3,7,8,9-HXCDD	460	100	na	0	0	na	5	7	0.272	22.2	49SS02
1,2,3,4,6,7,8-HPCDD	na	na	na	na	na	na	7	7	3.37	1110	49SS02
OCDD	na	na	na	na	na	na	7	7	295	10000	49SS02
1,2,3,7,8-PECDF	na	na	na	na	na	na	4	7	0.168	1.8	49SS03
2,3,4,7,8-PECDF	na	na	na	na	na	na	4	7	0.189	1.04	49SS05
1,2,3,4,7,8-HXCDF	na	na	na	na	na	na	4	7	0.791	8.47	49SS02
1,2,3,6,7,8-HXCDF	na	na	na	na	na	na	4	7	0.343	6.38	49SS02
2,3,4,6,7,8-HXCDF	na	na	na	na	na	na	4	7	0.422	8.25	49SS02
1,2,3,7,8,9-HXCDF	na	na	na	na	na	na	3	7	0.833	1.3	49SS02
1,2,3,4,6,7,8-HPCDF	na	na	na	na	na	na	7	7	0.883	214	49SS02
1,2,3,4,7,8,9-HPCDF	na	na	na	na	na	na	4	7	0.718	13.7	49SS02
OCDF	na	na	na	na	na	na	7	7	1.9	736	49SS02
TOTAL TCDD	na	na	na	na	na	na	4	7	1.2	18.6	49SS03
TOTAL PECDD	na	na	na	na	na	na	4	7	1.13	14.4	49SS02
TOTAL HXCDD	na	na	na	na	na	na	6	7	1.06	148	49SS02
TOTAL HPCDD	na	na	na	na	na	na	7	7	5.79	1670	49SS02
TOTAL TCDF	na	na	na	na	na	na	7	7	0.391	17.8	49SS03
TOTAL PECDF	na	na	na	na	na	na	4	7	2.94	46.3	49SS02
TOTAL HXCDF	na	na	na	na	na	na	7	7	0.228	221	49SS02
TOTAL HPCDF	na	na	na	na	na	na	7	7	1.57	719	49SS02

Table 4-3
Analytes Detected in the Combined Site Area Groundwater Samples - 2007 RFI
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Analyte	Sample ID Sample Date		48MW1 8/29/07					48MW2 8/29/07					48MW3 8/29/07					48MW4 8/29/07					48MW05 8/30/07					48MW06 8/30/07					48MW07 8/30/07				
	MCL	tw-SL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																																					
1,1,1-Trichloroethane	200	750	0.46	J	J	*0.29*	*1*	1	U		*0.29*	*1*	1	U		*0.29*	*1*	1	U		*0.29*	*1*	1	U		*0.29*	*1*	1.8			*0.29*	*1*	1	U		*0.29*	*1*
1,1-Dichloroethane	na	2.4	1	U		*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*	3.4			*0.25*	*1*	1	U		*0.25*	*1*
Carbon tetrachloride	5	0.39	1	U		*0.29*	*1*	94.6			*0.29*	*1*	60.3			*0.29*	*1*	1	U		*0.29*	*1*	1	U		*0.29*	*1*	1	U		*0.29*	*1*	1	U		*0.29*	*1*
cis-1,2-Dichloroethene	70	2.8	1	U		*0.28*	*1*	1	U		*0.28*	*1*	1	U		*0.28*	*1*	1	U		*0.28*	*1*	1	U		*0.28*	*1*	2.9			*0.28*	*1*	1	U		*0.28*	*1*
Tetrachloroethene	5	0.072	1	U		*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*	2.3			*0.25*	*1*	1	U		*0.25*	*1*	1	U		*0.25*	*1*
Trichloroethene	5	0.44	1.6			*0.38*	*1*	11.2			*0.38*	*1*	10.1			*0.38*	*1*	1	U		*0.38*	*1*	1	U		*0.38*	*1*	3.7			*0.38*	*1*	1	U		*0.38*	*1*
PAHs (ug/L)	None detected																																				
SVOCs (ug/L)																																					
bis(2-Ethylhexyl)phthalate	6	0.071	5.1	U		*2*	*5.1*	5	U		*2*	*5*	4.9	U		*2*	*4.9*	4.9	U		*2*	*4.9*	5.1	U		*2*	*5.1*	4.9	U		*2*	*4.9*	4.9	U		*2*	*4.9*
Pesticides (ug/L)	None detected																																				
PCBs (ug/L)	None detected																																				
Explosives (ug/L)	None detected																																				
Herbicides (ug/L)	None detected																																				
Metals (ug/L)																																					
Aluminum	50	16000	79	U		*79*	*200*	14300			*79*	*200*	79	U		*79*	*200*	79	U		*79*	*200*	61500			*79*	*200*	26600			*79*	*200*	457			*79*	*200*
Antimony	6	0.6	3.3	U		*3.3*	*6*	3.3	U		*3.3*	*6*	3.3	U		*3.3*	*6*	3.3	U		*3.3*	*6*	6.3		B	*3.3*	*6*	6.9		B	*3.3*	*6*	3.3	U		*3.3*	*6*
Arsenic	10	0.045	3.7	U		*3.7*	*10*	4.4	J	J	*3.7*	*10*	3.7	U		*3.7*	*10*	3.7	U		*3.7*	*10*	16.3			*3.7*	*10*	11.9			*3.7*	*10*	3.7	U		*3.7*	*10*
Barium	2000	290	75.5	J	J	*5*	*200*	607			*5*	*200*	66	J	J	*5*	*200*	148	J	J	*5*	*200*	5560			*50*	*2000*	335			*5*	*200*	76.8	J	J	*5*	*200*
Beryllium	4	1.6	1	U		*1*	*4*	1	U		*1*	*4*	1	U		*1*	*4*	1	U		*1*	*4*	3.8	J	K	*1*	*4*	1.5	J	K	*1*	*4*	1	U		*1*	*4*
Cadmium	5	0.69	1	U		*1*	*5*	1	U		*1*	*5*	1	U		*1*	*5*	1	U		*1*	*5*	5			*1*	*5*	1	U		*1*	*5*	1	U		*1*	*5*
Calcium	na	na	96400			*100*	*1000*	185000			*100*	*1000*	93600		L	*100*	*1000*	58900		L	*100*	*1000*	1560000			*1000*	*10000*	157000			*100*	*1000*	22200			*100*	*1000*
Chromium	100	1600	9.9	J	J	*0.92*	*10*	195			*0.92*	*10*	8.1	J	J	*0.92*	*10*	9.4	J	J	*0.92*	*10*	397			*0.92*	*10*	140			*0.92*	*10*	11.9			*0.92*	*10*
Cobalt	na	0.47	1	U		*1*	*50*	13.8	J	J	*1*	*50*	1	U		*1*	*50*	1	U		*1*	*50*	135			*1*	*50*	42.8	J	J	*1*	*50*	1	U		*1*	*50*
Copper	1300	62	1.2	U		*1.2*	*25*	19.7	J	J	*1.2*	*25*	1.2	U		*1.2*	*25*	1.2	U		*1.2*	*25*	53.7			*1.2*	*25*	119			*1.2*	*25*	1.2	J	B	*1.2*	*25*
Iron	300	1100	36	J	J	*15*	*300*	17200			*15*	*300*	15	U	UL	*15*	*300*	15	U	UL	*15*	*300*	137000			*15*	*300*	89800			*15*	*300*	861			*15*	*300*
Lead	15	na	2.1	U		*2.1*	*5*	2.1	U		*2.1*	*5*	3.5	J	B	*2.1*	*5*	2.1	J	B	*2.1*	*5*	29.7			*2.1*	*5*	8.4		B	*2.1*	*5*	2.1	J	B	*2.1*	*5*
Magnesium	na	na	44300			*100*	*5000*	109000			*100*	*5000*	42700			*100*	*5000*	51900			*100*	*5000*	762000			*1000*	*50000*	119000			*100*	*5000*	12100			*100*	*5000*
Manganese	50	32	7.4	J	J	*1*	*15*	286			*1*	*15*	7	J	J	*1*	*15*	8.6	J	J	*1*	*15*	4980			*10*	*150*	2550			*1*	*15*	32.3			*1*	*15*
Mercury	2	0.063	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*	0.11	U		*0.11*	*1*
Nickel	na	30	5.7	J	J	*1*	*40*	132			*1*	*40*	5	J	J	*1*	*40*	5.7	J	J	*1*	*40*	325			*1*	*40*	117			*1*	*40*	6.9	J	J	*1*	*40*
Potassium	na	na	1950	J	B	*100*	*10000*	6080	J	J	*100*	*10000*	3160	J	J	*100*	*10000*	3800	J	J	*100*	*10000*	18200			*100*	*10000*	9740	J	J	*100*	*10000*	2910	J	B	*100*	*10000*
Selenium	50	7.8	4	U		*4*	*10*	4	U		*4*	*10*	4	U		*4*	*10*	4	U		*4*	*10*	100	U		*100*	*200*	10		K	*4*	*10*	4	U		*4*	*10*
Silver	100	7.1	0.77	U		*0.77*	*10*	0.77	U		*0.77*	*10*	0.77	U		*0.77*	*10*	0.77	U		*0.77*	*10*	8.8	J	J	*0.77*	*10*	0.77	U		*0.77*	*10*	0.77	U		*0.77*	*10*
Sodium	na	na	2090	J	J	*500*	*10000*	2240	J	J	*500*	*10000*	3660	J	B	*500*	*10000*	12400		K	*500*	*10000*	19600			*500*	*10000*	60500			*500*	*10000*	2470	J	B	*500*	*10000*
Vanadium	na	7.8	1.1	J	J	*1.1*	*50*	35.6	J	J	*1.1*	*50*	1.1	U		*1.1*	*50*	1.1	U		*1.1*	*50*	73.9			*1.1*	*50*	46.3	J	J	*1.1*	*50*	1.1	U		*1.1*	*50*
Zinc	5000	470	6.3	J	J	*5*	*20*	36.5			*5*	*20*	5	U		*5*	*20*	5	U		*5*	*20*	93.6			*5*	*20*	41.8			*5*	*20*	5	U		*5*	*20*
Dioxins/Furans (ug/L)																																					
2,3,7,8-TCDF	na	na	0.00271	U		*2.71*	*2.71*	0.00262	U		*2.62*	*2.62*	0.00233	U		*2.33*	*2.33*	0.00237	U		*2.37*	*2.37*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00253	U		*2.53*	*2.53*
2,3,7,8-TCDD	0.03	0.00052	0.00409	U		*4.09*	*4.09*	0.0031	U		*3.1*	*3.1*	0.00305	U		*3.05*	*3.05*	0.00272	U		*2.72*	*2.72*	0.00344	U		*3.44*	*3.44*	0.00196	U		*1.96*	*1.96*	0.00369	U		*3.69*	*3.69*
1,2,3,7,8-PECDD	na	na	0.00514	U	UJ	*5.14*	*5.14*	0.00524	U	UJ	*5.24*	*5.24*	0.00483	U	UJ	*4.83*	*4.83*	0.00482	U	UJ	*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,4,7,8-HXCDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,6,7,8-HXCDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,7,8,9-HXCDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,4,6,7,8-HPCDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00816	U		*8.16*	*8.16*	0.00508	U		*5.08*	*5.08*	0.00801	U		*8.01*	*8.01*
OCDD	na	na	0.00652	A, EMPC	J	*10.3*	*10.3*	0.048	A	J	*NA*	*NA*	0.00965	U		*9.65*	*9.65*	0.00743	A	J	*NA*	*NA*	0.018	U		*18*	*18*	0.00859	A	J	*NA*	*NA*	0.0146	A	J	*NA*	*NA*
1,2,3,7,8-PECDF	na	na	0.00514	U	UJ	*5.14*	*5.14*	0.00524	U	UJ	*5.24*	*5.24*	0.00483	U	UJ	*4.83*	*4.83*	0.00482	U	UJ	*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
2,3,4,7,8-PECDF	na	na	0.00514	U	UJ	*5.14*	*5.14*	0.00524	U	UJ	*5.24*	*5.24*	0.00483	U	UJ	*4.83*	*4.83*	0.00482	U	UJ	*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,4,7,8-HXCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,6,7,8-HXCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
2,3,4,6,7,8-HXCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,7,8,9-HXCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
1,2,3,4,6,7,8-HPCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00177	A	J	*NA*	*NA*	0.00494	U		*4.94*	*4.94*
1,2,3,4,7,8,9-HPCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00584	U		*5.84*	*5.84*	0.00508	U		*5.08*	*5.08*	0.00594	U		*5.94*	*5.94*
OCDF	na	na	0.0103	U		*10.3*	*10.3*	0.0105	U		*10.5*	*10.5*	0.00965	U		*9.65*	*9.65*	0.00964	U		*9.64*	*9.64*	0.0129	U		*12.9*	*12.9*	0.0102	U		*10.2*	*10.2*	0.0127	U		*12.7*	*12.7*
TOTAL TCDD	na	na	0.00409	U		*4.09*	*4.09*	0.0031	U		*3.1*	*3.1*	0.00305	U		*3.05*	*3.05*	0.00272	U		*2.72*	*2.72*	0.00344	U		*3.44*	*3.44*	0.00196	U		*1.96*	*1.96*	0.00369	U		*3.69*	*3.69*
TOTAL PECDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
TOTAL HXCDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
TOTAL HPCDD	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00816	U		*8.16*	*8.16*	0.00508	U		*5.08*	*5.08*	0.00801	U		*8.01*	*8.01*
TOTAL TCDF	na	na	0.00271	U		*2.71*	*2.71*	0.00262	U		*2.62*	*2.62*	0.00233	U		*2.33*	*2.33*	0.00237	U		*2.37*	*2.37*	0.00246	U		*2.46*	*2.46*	0.00148	U		*1.48*	*1.48*	0.00253	U		*2.53*	*2.53*
TOTAL PECDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
TOTAL HXCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00538	U		*5.38*	*5.38*	0.00508	U		*5.08*	*5.08*	0.00494	U		*4.94*	*4.94*
TOTAL HPCDF	na	na	0.00514	U		*5.14*	*5.14*	0.00524	U		*5.24*	*5.24*	0.00483	U		*4.83*	*4.83*	0.00482	U		*4.82*	*4.82*	0.00584	U		*5.84*	*5.84*	0.00177			*5.08*	*5.08*	0.00594	U		*5.94*	*5.94*
Misc. (ug/L)																																					
Perchlorate	na	2.6	0.19	J	J	*0.0663*	*0.2*	0.548		J	*0.0663*	*0.2*	0.407		J	*0.0663*	*0.2*	0.311		J	*0.0663*	*0.2*	0.186	J	J	*0.0663*	*0.2*	0.236		J	*0.0663*	*0.2*	0.313		J	*0.0663*	*0.2*

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-3
Analytes Detected in the Combined Site Area Groundwater Samples - 2007 RFI
Page 2 of 2

Analyte	Sample ID	Sample Date	49MW01 8/29/07					50MW01 8/30/07					50MW02 8/30/07					59MW01 8/29/07				
	MCL	tw-SL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																						
1,1,1-Trichloroethane	200	750	1	U		0.29	1	1	U		0.29	1	1	U		0.29	1	1	U		0.29	1
1,1-Dichloroethane	na	2.4	1	U		0.25	1	1	U		0.25	1	1	U		0.25	1	1	U		0.25	1
Carbon tetrachloride	5	0.39	3.8			0.29	1	1	U		0.29	1	2.7			0.29	1	1	U		0.29	1
cis-1,2-Dichloroethene	70	2.8	1	U		0.28	1	1	U		0.28	1	1	U		0.28	1	1	U		0.28	1
Tetrachloroethene	5	0.072	1	U		0.25	1	1	U		0.25	1	0.84	J	J	0.25	1	1	U		0.25	1
Trichloroethene	5	0.44	1	U		0.38	1	1	U		0.38	1	3.4			0.38	1	1	U		0.38	1
PAHs (ug/L)	None detected																					
SVOCs (ug/L)																						
bis(2-Ethylhexyl)phthalate	6	0.071	5	U		2	5	5.1	U		2	5.1	8			2	4.9	5	U		2	5
Pesticides (ug/L)	None detected																					
PCBs (ug/L)	None detected																					
Explosives (ug/L)	None detected																					
Herbicides (ug/L)	None detected																					
Metals (ug/L)																						
Aluminum	50	16000	437			79	200	38600			79	200	8210			79	200	725			79	200
Antimony	6	0.6	3.3	U		3.3	6	12	U		12	24	3.3	U		3.3	6	3.3	U		3.3	6
Arsenic	10	0.045	3.7	U		3.7	10	9.1	J	J	3.7	10	3.7	U		3.7	10	3.7	U		3.7	10
Barium	2000	290	137	J	J	5	200	357			5	200	191	J	J	5	200	214			5	200
Beryllium	4	1.6	1	U		1	4	1.8	J	K	1	4	1	U		1	4	1	U		1	4
Cadmium	5	0.69	1	U		1	5	3	J	J	1	5	1	U		1	5	1	U		1	5
Calcium	na	na	40800		L	100	1000	2770000			1000	10000	146000			100	1000	30700			100	1000
Chromium	100	1600	23.8			0.92	10	78.7			0.92	10	18.2			0.92	10	9.8	J	J	0.92	10
Cobalt	na	0.47	3.1	J	J	1	50	19.6	J	J	1	50	3.8	J	J	1	50	1	U		1	50
Copper	1300	62	1.2	U		1.2	25	17.8	J	B	1.2	25	9.3	J	B	1.2	25	1.2	U		1.2	25
Iron	300	1100	623		L	15	300	40900			15	300	8850			15	300	801			15	300
Lead	15	na	2.1	U		2.1	5	237			2.1	5	65.7			2.1	5	2.1	U		2.1	5
Magnesium	na	na	31000			100	5000	1720000			1000	50000	59100			100	5000	23800			100	5000
Manganese	50	32	15.1			1	15	1230			1	15	245			1	15	20.5			1	15
Mercury	2	0.063	0.11	U		0.11	1	0.13	J	J	0.11	1	0.11	U		0.11	1	0.11	U		0.11	1
Nickel	na	30	14.5	J	J	1	40	49.8			1	40	22.3	J	J	1	40	5.8	J	J	1	40
Potassium	na	na	3420	J	J	100	10000	19300			100	10000	6940	J	B	100	10000	2090	J	B	100	10000
Selenium	50	7.8	4	U		4	10	200	U		200	400	16	U		16	20	4	U		4	10
Silver	100	7.1	0.77	U		0.77	10	0.77	U		0.77	10	0.77	U		0.77	10	0.77	U		0.77	10
Sodium	na	na	11400		K	500	10000	19900			500	10000	14500			500	10000	1460	J	J	500	10000
Vanadium	na	7.8	1.1	U		1.1	50	138			1.1	50	18.5	J	J	1.1	50	1.8	J	J	1.1	50
Zinc	5000	470	5.4	J	J	5	20	223			5	20	137			5	20	5	U		5	20
Dioxins/Furans (ug/L)																						
2,3,7,8-TCDF	na	na	0.0038	A	J	NA	NA	0.00165	U		1.65	1.65	0.00337	A	J	NA	NA	0.00248	U		2.48	2.48
2,3,7,8-TCDD	0.03	0.00052	0.00471	U		4.71	4.71	0.00222	U		2.22	2.22	0.00389	U		3.89	3.89	0.00314	U		3.14	3.14
1,2,3,7,8-PECDD	na	na	0.005	U	UJ	5	5	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.00302	A	J	NA	NA
1,2,3,4,7,8-HXCDD	na	na	0.0057	U		5.7	5.7	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.0056	U		5.6	5.6
1,2,3,6,7,8-HXCDD	na	na	0.00543	U		5.43	5.43	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.0056	U		5.6	5.6
1,2,3,7,8,9-HXCDD	na	na	0.00571	U		5.71	5.71	0.00544	U		5.44	5.44	0.00501	A, EMPC	J	5.48	5.48	0.0056	U		5.6	5.6
1,2,3,4,6,7,8-HPCDD	na	na	0.011	A	J	NA	NA	0.00544	U		5.44	5.44	0.0338	A	J	NA	NA	0.0056	U		5.6	5.6
OCDD	na	na	0.391			NA	NA	0.0184	A	J	NA	NA	1.1			NA	NA	0.00703	A	J	NA	NA
1,2,3,7,8-PECDF	na	na	0.005	U	UJ	5	5	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.0037	A	J	NA	NA
2,3,4,7,8-PECDF	na	na	0.005	U	UJ	5	5	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.00298	A	J	NA	NA
1,2,3,4,7,8-HXCDF	na	na	0.00551	U		5.51	5.51	0.00544	U		5.44	5.44	0.00376	A	J	NA	NA	0.00307	A	J	NA	NA
1,2,3,6,7,8-HXCDF	na	na	0.00523	U		5.23	5.23	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.00271	A	J	NA	NA
2,3,4,6,7,8-HXCDF	na	na	0.00556	U		5.56	5.56	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.0019	A, EMPC	J	5.6	5.6
1,2,3,7,8,9-HXCDF	na	na	0.00653	U		6.53	6.53	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.00253	A	J	NA	NA
1,2,3,4,6,7,8-HPCDF	na	na	0.00594	A	J	NA	NA	0.00544	U		5.44	5.44	0.0238	A	J	NA	NA	0.00309	A	J	NA	NA
1,2,3,4,7,8,9-HPCDF	na	na	0.00594	U		5.94	5.94	0.00544	U		5.44	5.44	0.00691	U		6.91	6.91	0.0056	U		5.6	5.6
OCDF	na	na	0.0109	A, EMPC	J	10.5	10.5	0.0109	U		10.9	10.9	0.0513	A	J	NA	NA	0.0112	U		11.2	11.2
TOTAL TCDD	na	na	0.00471	U		4.71	4.71	0.00222	U		2.22	2.22	0.00389	U		3.89	3.89	0.00314	U		3.14	3.14
TOTAL PECDD	na	na	0.005	U		5	5	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.00302			NA	NA
TOTAL HXCDD	na	na	0.00571	U		5.71	5.71	0.00544	U		5.44	5.44	0.0197			NA	NA	0.0056	U		5.6	5.6
TOTAL HPCDD	na	na	0.02			NA	NA	0.00544	U		5.44	5.44	0.0802			NA	NA	0.0056	U		5.6	5.6
TOTAL TCDF	na	na	0.0038			NA	NA	0.00165	U		1.65	1.65	0.00509			NA	NA	0.00248	U		2.48	2.48
TOTAL PECDF	na	na	0.005	U		5	5	0.00544	U		5.44	5.44	0.00546	U		5.46	5.46	0.00667			NA	NA
TOTAL HXCDF	na	na	0.00653	U		6.53	6.53	0.00544	U		5.44	5.44	0.00704			NA	NA	0.0102			NA	NA
TOTAL HPCDF	na	na	0.00594			NA	NA	0.00544	U		5.44	5.44	0.0238			NA	NA	0.00309			NA	NA
Misc. (ug/L)																						
Perchlorate	na	2.6	0.193	J	J	0.0663	0.2	0.203		J	0.0663	0.2	0.288		J	0.0663	0.2	0.283		J	0.0663	0.2

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-3
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-SL exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-SLs for carcinogenic compounds are shown in red font.
tw-SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.
MCL Action Levels were used for copper and lead.
MCL Source: 2011 Edition of the Drinking Water Standards and Health Advisories. USEPA. Winter 2011.
tw-SL Source: ORNL Regional Screening Table. November 2011.
µg/L = micrograms per liter (parts per billion).
NA = not applicable.

Lab Q = Lab Data Qualifiers
A (dioxins) = Value <MRL and >MDL and is considered estimated.
EMPC (dioxins) = The ion-abundance ratio between the two characteristic PCDDPCDF ions was outside accepted ranges. The detected PCDD/PCDF was reported as an estimated maximum possible concentration (EMPC).
J = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
UJ = Estimated concentration non-detect.
UL = Estimated concentration non-detect bias low.

Table 4-4
Summary of Analytes Detected in the Combined Site Area Groundwater Samples - 2007 RFI

Analyte	MCL	tw-SL	# of MCL Exceedances	# of tw-SL Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/L)									
1,1,1-Trichloroethane	200	750	0	0	2	11	0.46	1.8	48MW06
1,1-Dichloroethane	na	2.4	na	1	1	11	3.4	3.4	48MW06
Carbon tetrachloride	5	0.39	2	4	4	11	2.7	94.6	48MW2
cis-1,2-Dichloroethene	70	2.8	0	1	1	11	2.9	2.9	48MW06
Tetrachloroethene	5	0.072	0	2	2	11	0.84	2.3	48MW05
Trichloroethene	5	0.44	2	5	5	11	1.6	11.2	48MW2
PAHs (ug/L)	***None detected***								
SVOCs (ug/L)									
bis(2-Ethylhexyl)phthalate	6	0.071	1	1	1	11	8	8	50MW02
Pesticides (ug/L)	***None detected***								
PCBs (ug/L)	***None detected***								
Explosives (ug/L)	***None detected***								
Herbicides (ug/L)	***None detected***								
Metals (ug/L)									
Aluminum	50	16000	8	3	8	11	437	61500	48MW05
Antimony	6	0.6	2	2	2	11	6.3	6.9	48MW06
Arsenic	10	0.045	2	4	4	11	4.4	16.3	48MW05
Barium	2000	290	1	4	11	11	66	5560	48MW05
Beryllium	4	1.6	0	2	3	11	1.5	3.8	48MW05
Cadmium	5	0.69	1	2	2	11	3	5	48MW05
Calcium	na	na	na	na	11	11	22200	2770000	50MW01
Chromium	100	1600	3	0	11	11	8.1	397	48MW05
Cobalt	na	0.47	na	6	6	11	3.1	135	48MW05
Copper	1300	62	0	1	6	11	1.2	119	48MW06
Iron	300	1100	8	5	9	11	36	137000	48MW05
Lead	15	na	3	na	7	11	2.1	237	50MW01
Magnesium	na	na	na	na	11	11	12100	1720000	50MW01
Manganese	50	32	5	6	11	11	7	4980	48MW05
Mercury	2	0.063	0	1	1	11	0.13	0.13	50MW01
Nickel	na	30	na	4	11	11	5	325	48MW05
Potassium	na	na	na	na	11	11	1950	19300	50MW01
Selenium	50	7.8	0	1	1	11	10	10	48MW06
Silver	100	7.1	0	1	1	11	8.8	8.8	48MW05
Sodium	na	na	na	na	11	11	1460	60500	48MW06
Vanadium	na	7.8	na	5	7	11	1.1	138	50MW01
Zinc	5000	470	0	0	7	11	5.4	223	50MW01
Dioxins/Furans (ug/L)									
2,3,7,8-TCDF	na	na	na	na	2	11	0.00337	0.0038	49MW01
1,2,3,7,8-PECDD	na	na	na	na	1	11	0.00302	0.00302	59MW01
1,2,3,7,8,9-HXCDD	na	0.011	na	0	1	11	0.00501	0.00501	50MW02
1,2,3,4,6,7,8-HPCDD	na	na	na	na	2	11	0.011	0.0338	50MW02
OCDD	na	na	na	na	9	11	0.00652	1.1	50MW02
1,2,3,7,8-PECDF	na	na	na	na	1	11	0.0037	0.0037	59MW01
2,3,4,7,8-PECDF	na	na	na	na	1	11	0.00298	0.00298	59MW01
1,2,3,4,7,8-HXCDF	na	na	na	na	2	11	0.00307	0.00376	50MW02
1,2,3,6,7,8-HXCDF	na	na	na	na	1	11	0.00271	0.00271	59MW01
2,3,4,6,7,8-HXCDF	na	na	na	na	1	11	0.0019	0.0019	59MW01
1,2,3,7,8,9-HXCDF	na	na	na	na	1	11	0.00253	0.00253	59MW01
OCDF	na	na	na	na	2	11	0.0109	0.0513	50MW02
TOTAL PECDD	na	na	na	na	1	11	0.00302	0.00302	59MW01
TOTAL HXCDD	na	na	na	na	1	11	0.0197	0.0197	50MW02
TOTAL HPCDD	na	na	na	na	2	11	0.02	0.0802	50MW02
TOTAL TCDF	na	na	na	na	2	11	0.0038	0.00509	50MW02
TOTAL PECDF	na	na	na	na	1	11	0.00667	0.00667	59MW01
TOTAL HXCDF	na	na	na	na	2	11	0.00704	0.0102	59MW01
TOTAL HPCDF	na	na	na	na	4	11	0.00177	0.0238	50MW02
Misc. (ug/L)									
Perchlorate	na	2.6	na	0	11	11	0.186	0.548	48MW2

SVOCs. One SVOC (di-n-butylphthalate) was detected in two site soil samples (49SS02 and 49SS03). However, the concentrations were well below the adjusted i-SLs and r-SLs.

Pesticides. Pesticides were not detected in site soil samples.

PCBs. Two PCBs (PCB-1254 and PCB-1260) were detected in soil samples. PCB-1254 was only detected in samples 49SS03, 49SS04, and 49SS05. PCB-1260 was only detected in sample 49SS02. All concentrations were well below the adjusted i-SLs and r-SLs.

Explosives. Explosives were not detected in the soil samples.

Herbicides. One herbicide (2,4-DB) was detected in one surface soil sample (49SS03) at a concentration well below the adjusted SLs.

TAL Inorganics. Twenty-one TAL metals were detected in site soil samples. None of the detected metals were present at concentrations above both background and r-SLs or i-SLs.

Dioxins/Furans. Seventeen dioxins/furans were detected in the site soil samples. None of the detected dioxins/furans exceeded their respective i-SL or r-SL. Calculated TCDD Toxicity Equivalents (TE) values are discussed in *Section 6.1.1* of the HHRA.

4.1.2 Groundwater Analytical Results

Four groundwater samples (48MW1, 48MW2, 48MW3, and 48MW4) were collected from four existing wells and seven samples (48MW05, 48MW06, 48MW07, 49MW01, 50MW01, 50MW02, and 59MW01) were collected from the newly-installed wells for chemical analysis (see **Table 3-1**). Detected groundwater results from the 2007 RFI sampling event for SWMUs 48, 49, 50, and 59 are presented in **Table 4-3** and summarized in **Table 4-4**.

VOCs. Six VOCs [1,1,1-trichloroethane; 1,1-dichloroethane (DCA); CT; cis-1,2-DCE; PCE; and TCE] were detected in the combined site groundwater samples. Two VOCs (CT and TCE) were detected above their SLs in the groundwater samples. CT and TCE were found above their MCLs and tw-SLs in SWMU 49 wells 48MW2 and 48MW3. In addition, concentrations of 1,1-DCA exceeded the tw-SL in 48MW06. Concentrations of CT exceeded the tw-SL in samples 48MW2, 48MW3, 49MW01, and 50MW02. Concentrations of cis-1,2-DCE exceeded the tw-SL in 48MW06. PCE concentrations exceeded the tw-SL in samples 48MW05 and 50MW02, and TCE exceeded its tw-SL in samples 48MW1 (a SWMU 49 well), 48MW2, 48MW3, 48MW06, and 50MW02.

PAHs. PAHs were not detected in the combined-site groundwater samples.

SVOCs. One non-PAH SVOC [bis(2-ethylhexyl)phthalate] was detected in the combined-site groundwater samples. It was detected above its MCL and tw-SL in sample 50MW02. It should be noted that bis(2-ethylhexyl)phthalate is a common laboratory contaminant, and its presence in groundwater at the site is not considered to be site related.

Pesticides. Pesticides were not detected in the combined-site groundwater samples.

PCBs. PCBs were not detected in the combined-site groundwater samples.

Explosives. Explosives were not detected in the combined-site groundwater samples.

Herbicides. Herbicides were not detected in the combined-site groundwater samples.

Metals. Twenty-two metals were detected in the combined-site groundwater samples. Seven of these metals (aluminum, antimony, arsenic, barium, cadmium, iron, and manganese) were detected at concentrations above both their respective tw-SL and the MCL. Fifteen metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, manganese, mercury, nickel, selenium, silver, and vanadium) were detected at concentrations above their tw-SLs. One metal without a tw-SL (lead) was detected at concentrations above its MCL.

Dioxin/Furans. Nineteen dioxins/furans were detected in the combined-site groundwater samples. However, none of the total dioxins/furans were detected at a concentration above associated MCLs or tw-SLs. Calculated TCDD TE values are discussed in *Section 6.1.1*, HHRA.

Misc. Perchlorate was detected in all 11 groundwater samples. However, concentrations were below its tw-SL in all of the samples. It should be noted that perchlorate has consistently been detected at low levels throughout Radford since the adoption of the new liquid chromatography/mass spectrometry analytical method.

4.2 Interim Measures, Shaw, 2011

4.2.1 SWMU 48 Soil Confirmation Results

Five soil samples (48SC01 through 48SC05) were collected from the bottom and sidewalls of the excavation to confirm that all contaminated soil has been completely removed from the excavated area(s) at SWMU 48. Confirmation soil samples were shipped to an off-site laboratory and analyzed for TAL metals and explosives. Detected results are presented in **Table 4-5** and summarized in **Table 4-6**. There were no detections above the established RGs in any of the five soil samples.

Metals. Six metals (antimony, arsenic, cadmium, copper, lead, and mercury) were detected in the five samples. None of the detected metals were present at concentrations above the established RGs.

Explosives. One explosive (2,4-DNT) was detected in one sample (48SC03). Although an RG was not established for 2,4-DNT, the detected concentration (0.1 mg/kg) was well below the r-SL (1.6 mg/kg) for 2,4-DNT.

4.3 SWMU 48/49 Supplemental RFI, Shaw, 2013

4.3.1 Groundwater Analytical Results

Fourteen groundwater samples were collected from 10 existing vicinity wells (48MW1, 48MW2, 48MW3, 48MW06, 49MW01, 50MW02, 13MW2, 13MW3, 13MW4, and 13MW5) and from the four newly-installed wells (49MW02, 49MW03, 49MW04, and 49MW05) to the south and east of SWMUs 48 and 49 for chemical analysis. The samples were analyzed for TCL VOCs, TAL metals (total and dissolved), dioxins/furans (two samples), and MNA parameters, including methane, ethane, ethene, chloride, nitrate, sulfate, and TOC. Detected groundwater results from the 2013 Supplemental RFI sampling event are presented in **Table 4-7** and summarized in **Table 4-8**.

VOCs. Eleven VOCs were detected in the 14 groundwater samples. Six VOCs (1,1-DCA; CT; chloroform; cis-1,2-DCE; PCE; and TCE) were detected above their tw-SLs in the groundwater samples. CT and TCE were found above their MCLs (and tw-SLs) in three SWMU 49 wells (48MW2, 48MW3, and 49MW02) and one SWMU 13 well (13MW3). Detected concentrations of CT ranged from 0.664 µg/L in well 49MW04 to 82.7 µg/L in well 48MW2. Detected concentrations of TCE ranged from 0.934 µg/L in well 49MW02 to 10.7 µg/L in well 48MW3.

Table 4-5
Analytes Detected in SWMU 48 Confirmation Soil Samples - 2011 Interim Measures

Analyte	Sample ID	**48SC01**					**48SC02**					**48SC03**					**48SC04**					**48SC05**				
	Sample Date	**11/17/11**					**11/17/11**					**11/17/11**					**11/17/11**					**11/17/11**				
	Sample Depth	**8-9**					**8-9**					**16-17**					**9-10**					**16-17**				
	RG	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
Explosives (mg/kg)																										
2,4-Dinitrotoluene	na	0.5	U		*0.08*	*0.5*	0.5	U		*0.08*	*0.5*	0.1	JP	J	*0.08*	*0.5*	0.5	U		*0.08*	*0.5*	0.5	U		*0.079*	*0.5*
Metals (mg/kg)																										
Aluminum	na	22700		J	*0.1*	*0.61*	33500		J	*0.1*	*0.6*	10200		J	*0.099*	*0.59*	25000		J	*0.099*	*0.59*	15100		J	*0.098*	*0.59*
Antimony	410	1.7		L	*0.16*	*1*	0.23	J	L	*0.16*	*1*	1.3		L	*0.16*	*0.99*	0.23	J	L	*0.16*	*0.99*	0.88	J	L	*0.16*	*0.98*
Arsenic	15.8	7.6		L	*0.33*	*2*	0.16	U	UL	*0.16*	*1*	5.1		L	*0.32*	*2*	2.3		L	*0.32*	*2*	0.16	U	UL	*0.16*	*0.98*
Barium	na	28.1		K	*0.023*	*0.13*	64.5		K	*0.023*	*0.13*	21		K	*0.022*	*0.12*	27.6		K	*0.022*	*0.12*	51.9		K	*0.022*	*0.12*
Beryllium	na	0.33			*0.01*	*0.1*	0.14			*0.01*	*0.1*	0.48			*0.009*	*0.099*	0.046	J	J	*0.009*	*0.099*	0.0049	U		*0.004*	*0.049*
Cadmium	800	0.85			*0.007*	*0.051*	0.0075	U		*0.007*	*0.05*	0.18			*0.007*	*0.049*	0.065			*0.007*	*0.05*	0.019	J	J	*0.007*	*0.049*
Calcium	na	685		J	*0.61*	*3.6*	1030		J	*0.6*	*3.5*	165		J	*0.59*	*3.5*	121		J	*0.59*	*3.5*	503		J	*0.59*	*3.4*
Chromium	na	27.5			*0.058*	*0.36*	13.1			*0.058*	*0.35*	38			*0.057*	*0.35*	14.6			*0.057*	*0.35*	11.9			*0.056*	*0.34*
Cobalt	na	6			*0.1*	*0.61*	2.4			*0.1*	*0.6*	2.8			*0.099*	*0.59*	3.2			*0.099*	*0.59*	5.9			*0.098*	*0.59*
Copper	41000	16.8		J	*0.18*	*1*	6.4		J	*0.18*	*1*	7.6		J	*0.17*	*0.99*	7.4		J	*0.17*	*0.99*	9.2		J	*0.17*	*0.98*
Iron	na	81200		J	*3.8*	*23*	14300		J	*0.75*	*4.5*	40300		J	*0.74*	*4.4*	47000		J	*0.74*	*4.5*	25000		J	*0.74*	*4.4*
Lead	800	13.5			*0.1*	*0.63*	5			*0.1*	*0.63*	5.8			*0.099*	*0.62*	12.3			*0.099*	*0.62*	8.6			*0.098*	*0.61*
Magnesium	na	452		J	*0.36*	*2*	1340		J	*0.35*	*2*	413		J	*0.35*	*2*	719		J	*0.35*	*2*	1550		J	*0.34*	*2*
Manganese	na	245			*0.063*	*0.38*	39.4			*0.063*	*0.38*	59.7			*0.062*	*0.37*	242			*0.062*	*0.37*	233			*0.061*	*0.37*
Mercury	43	0.041			*0.002*	*0.011*	0.016			*0.002*	*0.01*	0.007	J	J	*0.002*	*0.01*	0.038			*0.002*	*0.01*	0.0069	J	J	*0.002*	*0.01*
Nickel	na	6			*0.053*	*0.3*	6.3			*0.053*	*0.3*	4.3			*0.052*	*0.3*	4.9			*0.052*	*0.3*	6.3			*0.051*	*0.29*
Potassium	na	447			*14*	*84*	713			*14*	*83*	361			*14*	*81*	805			*14*	*82*	1320			*13*	*81*
Selenium	na	0.076	U	UL	*0.076*	*0.51*	0.21	J	L	*0.075*	*0.5*	0.15	J	L	*0.074*	*0.49*	2.9		L	*0.15*	*0.99*	0.21	J	L	*0.074*	*0.49*
Silver	na	0.022	U		*0.022*	*0.13*	0.021	U		*0.021*	*0.13*	0.021	U		*0.021*	*0.12*	0.021	U		*0.021*	*0.12*	0.021	U		*0.021*	*0.12*
Sodium	na	5.1	U		*5.1*	*30*	118			*5*	*30*	4.9	U		*4.9*	*30*	5	U		*5*	*30*	4.9	U		*4.9*	*29*
Thallium	na	0.1	J	J	*0.1*	*0.61*	0.1	U		*0.1*	*0.6*	0.18	J	J	*0.099*	*0.59*	0.099	U		*0.099*	*0.59*	0.098	U		*0.098*	*0.59*
Vanadium	na	57.9		J	*0.03*	*0.2*	30.9		J	*0.03*	*0.2*	24.5		J	*0.03*	*0.2*	55.4		J	*0.03*	*0.2*	43.5		J	*0.029*	*0.2*
Zinc	na	23		K	*0.13*	*0.76*	18.1		K	*0.13*	*0.75*	20		K	*0.12*	*0.74*	19.6		K	*0.12*	*0.74*	26.4		K	*0.12*	*0.74*

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-5
Legend

RGs for soil at SWMU 48 were established in Shaw (2011).
mg/kg = milligrams per kilogram (parts per million).
NA = not applicable.

Lab Q = Lab Data Qualifiers
J = Estimated result. Result is less than RL.
JP = The RPD between the original and confirmation analyses is greater than 40%. Value is estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
UL = Estimated concentration non-detect bias low.

Table 4-6
Summary of Analytes Detected in SWMU 48 Confirmation Soil Samples - 2011 Interim Measures

Analyte	RG	# of RG Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (mg/kg)							
2,4-Dinitrotoluene	na	na	1	5	0.1	0.1	48SC03
Metals (mg/kg)							
Antimony	410	0	5	5	0.23	1.7	48SC01
Arsenic	15.8	0	3	5	2.3	7.6	48SC01
Cadmium	800	0	4	5	0.019	0.85	48SC01
Copper	41000	0	5	5	6.4	16.8	48SC01
Lead	800	0	5	5	5	13.5	48SC01
Mercury	43	0	5	5	0.0069	0.041	48SC01

Table 4-7
Analytes Detected in 2013 Supplemental RFI Groundwater Samples
Page 1 of 2

Analyte	Sample ID		13MW2					13MW3					13MW4					13MW5					48MW1					48MW2					48MW3				
	Sample Date		5/6/13					5/6/13					5/6/13					5/6/13					5/8/13					5/9/13					5/9/13				
	MCL	**tw-SL**	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																																					
1,1,1-Trichloroethane	200	750	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.432	J	J	0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2
1,1-Dichloroethane	na	2.4	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	1.03			0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2
1,1-Dichloroethene	7	26	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5
Acetone	na	1200	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1
Carbon tetrachloride	5	0.39	0.5	U		0.248	0.5	5.63			0.248	0.5	0.5	U		0.248	0.5	0.5	U		0.248	0.5	0.5	U		0.248	0.5	82.7			0.248	0.5	73.1			0.248	0.5
Chloroform	80	0.19	0.2	U		0.155	0.2	0.453	J	J	0.155	0.2	0.2	U		0.155	0.2	0.2	U		0.155	0.2	0.2	U		0.155	0.2	5.97			0.155	0.2	7.89			0.155	0.2
cis-1,2-Dichloroethene	70	2.8	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.817	J	J	0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2
Methylene chloride	5	4.7	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5
Tetrachloroethene	5	0.072	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5
Toluene	1000	86	0.2	U		0.122	0.2	0.2	U		0.122	0.2	0.2	U		0.122	0.2	0.2	U		0.122	0.2	2.1			0.122	0.2	1.18			0.122	0.2	0.291	J	J	0.122	0.2
Trichloroethene	5	0.44	0.2	U		0.161	0.2	1.08			0.161	0.2	1.08			0.161	0.2	0.2	U		0.161	0.2	1.9			0.161	0.2	9.75			0.161	0.2	10.7			0.161	0.2
Total Metals (ug/L)																																					
Aluminum	50	16000	53.8		B	1.66	6	56.1		B	1.66	6	40.4		B	1.66	6	49.2		B	1.66	6	1730			1.66	6	726			1.66	6	86			1.66	6
Antimony	6	0.6	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1
Arsenic	10	0.045	0.28	J	B	0.094	0.3	0.1	J	B	0.094	0.3	0.16	J	B	0.094	0.3	0.11	J	B	0.094	0.3	1.12			0.094	0.3	0.39	J	J	0.094	0.3	0.25	J	J	0.094	0.3
Barium	2000	290	185			1.54	6	99.8			0.077	0.3	56.1			0.077	0.3	79.2			0.077	0.3	134			0.77	3	408			0.77	3	128			0.77	3
Cadmium	5	0.69	0.094	J	J	0.026	0.1	0.1	U		0.026	0.1	0.16	J	J	0.026	0.1	0.044	J	J	0.026	0.1	0.027	J	J	0.026	0.1	0.1	U		0.026	0.1	0.1	U		0.026	0.1
Calcium	na	na	91100			868	2000	83200			434	1000	46200			434	1000	88700			434	1000	53600		J	434	1000	72200			434	1000	94400		J	434	1000
Chromium	100	1600	9.15			0.03	0.1	13.1			0.03	0.1	2.87			0.03	0.1	9.71			0.03	0.1	31.6			0.03	0.1	29.8			0.03	0.1	4.04			0.03	0.1
Cobalt	na	0.47	0.22	J	B	0.053	0.2	1.58			0.053	0.2	0.29	J	B	0.053	0.2	0.21	J	B	0.053	0.2	4.54			0.053	0.2	1.24			0.053	0.2	0.25	J	B	0.053	0.2
Copper	1300	62	15.9			0.093	0.3	10.5		J	0.093	0.3	15.7		J	0.093	0.3	14.6		J	0.093	0.3	8.59			0.093	0.3	2.61			0.093	0.3	0.85	J	B	0.093	0.3
Iron	300	1100	122			3.04	10	168			3.04	10	86.1	J	J	3.04	10	128			3.04	10	2870			3.04	10	988			3.04	10	160			3.04	10
Lead	15	na	0.29	J	J	0.025	0.1	0.72	J	J	0.025	0.1	0.73	J	J	0.025	0.1	0.74	J	J	0.025	0.1	1.54			0.025	0.1	0.3	J	J	0.025	0.1	0.14	J	B	0.025	0.1
Magnesium	na	na	43200			104	400	33500			52.2	200	18100			52.2	200	31800			52.2	200	40900			52.2	200	36600			52.2	200	45400			52.2	200
Manganese	50	32	65			0.27	1	11.7			0.27	1	4.1	J	J	0.27	1	4.45	J	J	0.27	1	49.4			0.27	1	23.9			0.27	1	4.95	J	J	0.27	1
Nickel	na	30	2.5			0.26	1	6.65			0.26	1	2.26		J	0.26	1	4.05			0.26	1	21.3			0.26	1	19.8			0.26	1	2.88			0.26	1
Potassium	na	na	1050			9.98	30	2020			9.98	30	1000			9.98	30	1340			9.98	30	2280			9.98	30	1680			9.98	30	1410			9.98	30
Selenium	50	7.8	0.42	J	J	0.11	0.4	0.41	J	J	0.11	0.4	0.55	J	J	0.11	0.4	1.56		J	0.11	0.4	0.59	J	J	0.11	0.4	0.3	J	J	0.11	0.4	1.9		J	0.11	0.4
Silver	100	7.1	0.06	U		0.017	0.06	1.43			0.017	0.06	0.06	U		0.017	0.06	0.06	U		0.017	0.06	0.69	J	J	0.017	0.06	0.06	U		0.017	0.06	0.06	U		0.017	0.06
Sodium	na	na	3970			8	30	15100			80	300	16700			80	300	11600			80	300	16100			80	300	3320			8	30	1700			8	30
Thallium	2	0.016	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.12	J	J	0.06	0.2	0.11	J	J	0.06	0.2
Vanadium	na	7.8	1.18		B	0.085	0.3	0.84	J	B	0.085	0.3	0.68	J	B	0.085	0.3	0.71	J	B	0.085	0.3	3.74		J	0.085	0.3	2.53		B	0.085	0.3	1.35		B	0.085	0.3
Zinc	5000	470	48.7			1.31	5	17.5	J	J	1.31	5	34.6			1.31	5	42.3			1.31	5	30.5			1.31	5	3.6	J	J	1.31	5	5.06	J	J	1.31	5
Dissolved Metals (ug/L)																																					
Aluminum	50	16000	6.33	J	J	1.66	6	6	U		1.66	6	6	U		1.66	6	2.09	J	J	1.66	6	5.38	J	J	1.66	6	2.23	J	B	1.66	6	3.49	J	B	1.66	6
Antimony	6	0.6	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1
Arsenic	10	0.045	0.2	J	J	0.094	0.3	0.3	U		0.094	0.3	0.099	J	J	0.094	0.3	0.095	J	J	0.094	0.3	0.1	J	J	0.094	0.3	0.095	J	J	0.094	0.3	0.13	J	J	0.094	0.3
Barium	2000	290	171			1.54	6	91			0.077	0.3	51.2			0.077	0.3	76.3			0.077	0.3	104			0.77	3	401		K	0.77	3	110		K	0.77	3
Beryllium	4	1.6	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1
Calcium	na	na	82700			868	2000	74100			434	1000	40900			434	1000	81100			434	1000	43900			434	1000	59900			434	1000	76000			434	1000
Chromium	100	1600	6.9			0.03	0.1	1.15		B	0.03	0.1	1.73		B	0.03	0.1	3.89		B	0.03	0.1	1.27			0.03	0.1	1.05		B	0.03	0.1	1.17		B	0.03	0.1
Cobalt	na	0.47	0.1	J	J	0.053	0.2	1.16			0.053	0.2	0.18	J	J	0.053	0.2	0.092	J	J	0.053	0.2	0.75	J	J	0.053	0.2	0.23	J	J	0.053	0.2	0.077	J	J	0.053	0.2
Copper	1300	62	13			0.093	0.3	4.21			0.093	0.3	10.5			0.093	0.3	11.2			0.093	0.3	1.79			0.093	0.3	0.5	J	B	0.093	0.3	0.41	J	B	0.093	0.3
Iron	300	1100	22.1	J	B	3.04	10	19.7	J	B	3.04	10	13.1	J	B	3.04	10	23.2	J	B	3.04	10	19.3	J	B	3.04	10	20.1	J	B	3.04	10	23.4	J	B	3.04	10
Lead	15	na	0.044	J	B	0.025	0.1	0.034	J	B	0.025	0.1	0.068	J	B	0.025	0.1	0.087	J	B	0.025	0.1	0.031	J	B	0.025	0.1	0.034	J	B	0.025	0.1	0.1	U		0.025	0.1
Magnesium	na	na	39000			104	400	28900			52.2	200	16000			52.2	200	28100			52.2	200	32100			52.2	200	28300			52.2	200	35100			52.2	200
Manganese	50	32	1.23	J	J	0.27	1	9.28			0.27	1	1.14	J	J	0.27	1	1.25	J	J	0.27	1	6.11			0.27	1	3.32	J	J	0.27	1	0.33	J	J	0.27	1
Nickel	na	30	1.9		B	0.26	1	4.9			0.26	1	2.69		J	0.26	1	1.77		B	0.26	1	9.57			0.26	1	8.86			0.26	1	1.79		B	0.26	1
Potassium	na	na	901			9.98	30	1800			9.98	30	892			9.98	30	1240			9.98	30	1620			9.98	30	1430			9.98	30	1130			9.98	30
Selenium	50	7.8	0.42	J	J	0.11	0.4	0.39	J	J	0.11	0.4	0.54	J	J	0.11	0.4	1.8		J	0.11	0.4	0.35	J	J	0.11	0.4	0.43	J	B	0.11	0.4	2.62		J	0.11	0.4
Sodium	na	na	3760			8	30	14700			80	300	16200			80	300	11800		J	80	300	14600			80	300	3010			8	30	1410			8	30
Thallium	2	0.016	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.14	J	B	0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2
Vanadium	na	7.8	0.66	J	J	0.085	0.3	0.22	J	J	0.085	0.3	0.32	J	J	0.085	0.3	0.38	J	J	0.085	0.3	0.3	U		0.085	0.3	0.11	J	B	0.085	0.3	0.42	J	B	0.085	0.3
Zinc	5000	470	38.2			1.31	5	19.7	J	J	1.31	5	30.9			1.31	5	45.5			1.31	5	20			1.31	5	2.45	J	B	1.31	5	2.43	J	B	1.31	5
Dioxins/Furans (ug/L)	None detected																																				
Misc. (ug/L)																																					
Total Organic Carbon	na	na	1000	U		300	1000	1000	U		300	1000	1000	U		300	1000	660	J	J	300	1000	880	J	J	300	1000	310	J	J	300	1000	520	J	J	300	1000
Chloride	250000	na	4380			10	100	5530			20	200	5170			20	200	5610			20	200	4140			10	100	4980			10	100	3080			50	500
Nitrate (as N)	10000	5800	329	J	J	20	200	2050			20	200	1050			20	200	1540			20	200	1670			20	200	1060			20	200	6210			100	1000
Sulfate	250000	na	44000			200	2000	130000			400	4000	51300			400	4000	110000			400	4000	56700			400	4000	29600			100	1000	27300			200	2000
Methane	na	na	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09
Ethane	na	na	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22
Ethene	na	na	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-7
Analytes Detected in 2013 Supplemental RFI Groundwater Samples
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Analyte	Sample ID Sample Date		48MW06 5/7/13					49MW01 5/8/13					49MW02 5/9/13					49MW03 5/7/13					49MW04 5/6/13					49MW05 5/6/13					50MW02 5/8/13				
	MCL	tw-SL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL	Result	Lab Q	Val Q	MDL	MRL
VOCs (ug/L)																																						
1,1,1-Trichloroethane	200	750	1.66			0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.2	U	UL	0.123	0.2	0.2	U		0.123	0.2	0.2	U		0.123	0.2	0.251	J	J	0.123	0.2
1,1-Dichloroethane	na	2.4	5.86			0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.2	U	UL	0.171	0.2	0.2	U		0.171	0.2	0.2	U		0.171	0.2	0.344	J	J	0.171	0.2
1,1-Dichloroethene	7	26	0.301	J	J	0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U	UL	0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5	0.5	U		0.2	0.5
Acetone	na	1200	1	U		0.193	1	1	U		0.193	1	2.41	J	B	0.193	1	1	U	UL	0.193	1	1	U		0.193	1	1	U		0.193	1	1	U		0.193	1
Carbon tetrachloride	5	0.39	0.5	U		0.248	0.5	4.61			0.248	0.5	5.36			0.248	0.5	0.5	U	UL	0.248	0.5	0.664	J	J	0.248	0.5	0.5	U		0.248	0.5	0.919	J	J	0.248	0.5
Chloroform	80	0.19	0.2	U		0.155	0.2	0.193	J	J	0.155	0.2	7.79			0.155	0.2	0.2	U	UL	0.155	0.2	1.25			0.155	0.2	0.2	U		0.155	0.2	0.2	U		0.155	0.2
cis-1,2-Dichloroethene	70	2.8	9.21			0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.2	U	UL	0.103	0.2	0.2	U		0.103	0.2	0.2	U		0.103	0.2	0.373	J	J	0.103	0.2
Methylene chloride	5	4.7	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	2.3	J	L	0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5	0.5	U		0.149	0.5
Tetrachloroethene	5	0.072	0.801	J	J	0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.5	U	UL	0.193	0.5	0.5	U		0.193	0.5	0.5	U		0.193	0.5	0.255	J	J	0.193	0.5
Toluene	1000	86	0.2	U		0.122	0.2	0.765	J	J	0.122	0.2	1.52			0.122	0.2	0.2	U	UL	0.122	0.2	0.2	U		0.122	0.2	0.2	U		0.122	0.2	0.726	J	J	0.122	0.2
Trichloroethene	5	0.44	6.25			0.161	0.2	0.2	U		0.161	0.2	0.934	J	J	0.161	0.2	0.2	U	UL	0.161	0.2	0.2	U		0.161	0.2	0.2	U		0.161	0.2	2.31			0.161	0.2
Total Metals (ug/L)																																						
Aluminum	50	16000	14.7	J	B	1.66	6	1050			1.66	6	16.4	J	B	1.66	6	39.2		B	1.66	6	34.5		B	1.66	6	1530		J	1.66	6	519		J	1.66	6
Antimony	6	0.6	1	U		0.48	1	1	U		0.48	1	3.53			0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1
Arsenic	10	0.045	0.14	J	B	0.094	0.3	0.53	J	J	0.094	0.3	1.56			0.094	0.3	0.3	U		0.094	0.3	0.25	J	B	0.094	0.3	0.74	J	B	0.094	0.3	0.36	J	J	0.094	0.3
Barium	2000	290	129		J	1.54	6	48.4			0.077	0.3	129			0.77	3	191			0.77	3	82			0.077	0.3	170			0.77	3	105			0.77	3
Cadmium	5	0.69	0.1	U		0.026	0.1	0.1	U		0.026	0.1	0.1	U		0.026	0.1	0.1	U		0.026	0.1	0.1	U		0.026	0.1	0.1	U		0.026	0.1	0.1	U		0.026	0.1
Calcium	na	na	102000			868	2000	42600			434	1000	56100		J	434	1000	50700		J	434	1000	73000			434	1000	65600			434	1000	87300		J	434	1000
Chromium	100	1600	0.7	J	J	0.03	0.1	11.8			0.03	0.1	0.47	J	B	0.03	0.1	17.3		J	0.03	0.1	5.56			0.03	0.1	6.88			0.03	0.1	5.01		J	0.03	0.1
Cobalt	na	0.47	0.83	J	J	0.053	0.2	3.15			0.053	0.2	1.42		J	0.053	0.2	2			0.053	0.2	0.35	J	J	0.053	0.2	1.06			0.053	0.2	0.39	J	J	0.053	0.2
Copper	1300	62	0.77	J	B	0.093	0.3	8.58			0.093	0.3	0.98	J	B	0.093	0.3	2.83		J	0.093	0.3	14.8			0.093	0.3	2.3		J	0.093	0.3	2.09		J	0.093	0.3
Iron	300	1100	56.4	J	J	3.04	10	2540			3.04	10	17.9	J	J	3.04	10	142			3.04	10	66.8	J	J	3.04	10	2080			3.04	10	652		J	3.04	10
Lead	15	na	0.037	J	B	0.025	0.1	0.68	J	J	0.025	0.1	0.034	J	B	0.025	0.1	0.12	J	B	0.025	0.1	0.17	J	B	0.025	0.1	1.51			0.025	0.1	5.27		J	0.025	0.1
Magnesium	na	na	49900			104	400	39900			52.2	200	34800			52.2	200	22700			52.2	200	40600			52.2	200	33900			52.2	200	36100			52.2	200
Manganese	50	32	19.7			0.27	1	67.8			0.27	1	36.4			0.27	1	6.58			0.27	1	4.99	J	J	0.27	1	65.1			0.27	1	12.8		J	0.27	1
Nickel	na	30	5.61		J	0.26	1	8.34			0.26	1	40.1			0.26	1	8.27		J	0.26	1	4.74			0.26	1	4.52			0.26	1	3.74		J	0.26	1
Potassium	na	na	6040			9.98	30	1670			9.98	30	3010			9.98	30	1870			9.98	30	4860			9.98	30	2140			9.98	30	2190			9.98	30
Selenium	50	7.8	0.56	J	J	0.11	0.4	0.2	J	J	0.11	0.4	10.2		J	0.11	0.4	0.4	U		0.11	0.4	0.33	J	J	0.11	0.4	0.41	J	J	0.11	0.4	0.36	J	J	0.11	0.4
Silver	100	7.1	0.06	U		0.017	0.06	0.06	U		0.017	0.06	0.06	U		0.017	0.06	2.45			0.017	0.06	0.06	U		0.017	0.06	0.06	U		0.017	0.06	0.06	U		0.017	0.06
Sodium	na	na	79800			160	600	673	J	J	8	30	8280			8	30	2180			8	30	2180			8	30	2060			8	30	15200			80	300
Thallium	2	0.016	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.16	J	J	0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.16	J	B	0.06	0.2	0.2	U		0.06	0.2
Vanadium	na	7.8	0.22	J	B	0.085	0.3	2.23		B	0.085	0.3	1.1		B	0.085	0.3	0.59	J	B	0.085	0.3	0.62	J	B	0.085	0.3	3.79			0.085	0.3	2.16		B	0.085	0.3
Zinc	5000	470	5.61	J	J	1.31	5	1.75	J	J	1.31	5	5	U		1.31	5	8.29	J	J	1.31	5	21.3			1.31	5	8.01	J	J	1.31	5	13.2	J	J	1.31	5
Dissolved Metals (ug/L)																																						
Aluminum	50	16000	6	U		1.66	6	5.02	J	B	1.66	6	11	J	B	1.66	6	4.19	J	J	1.66	6	3.52	J	J	1.66	6	5.4	J	J	1.66	6	4	J	J	1.66	6
Antimony	6	0.6	1	U		0.48	1	1	U		0.48	1	3.84			0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1	1	U		0.48	1
Arsenic	10	0.045	0.3	U		0.094	0.3	0.3	U		0.094	0.3	1.5			0.094	0.3	0.3	U		0.094	0.3	0.18	J	J	0.094	0.3	0.29	J	J	0.094	0.3	0.3	U		0.094	0.3
Barium	2000	290	193		J	1.54	6	43.6		K	0.077	0.3	134		K	0.77	3	171			0.77	3	76.2			0.077	0.3	115			0.77	3	102			0.77	3
Beryllium	4	1.6	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1	0.1	U		0.049	0.1
Calcium	na	na	93000			868	2000	32700			434	1000	56800			434	1000	43300			434	1000	66000			434	1000	55300			434	1000	80000			434	1000
Chromium	100	1600	1.06		B	0.03	0.1	1.22		B	0.03	0.1	0.53	J	B	0.03	0.1	1.18			0.03	0.1	0.52	J	B	0.03	0.1	0.4	J	B	0.03	0.1	1	J	J	0.03	0.1
Cobalt	na	0.47	0.36	J	J	0.053	0.2	0.12	J	J	0.053	0.2	2.02		J	0.053	0.2	0.75	J	J	0.053	0.2	0.24	J	J	0.053	0.2	0.26	J	J	0.053	0.2	0.082	J	J	0.053	0.2
Copper	1300	62	0.35	J	B	0.093	0.3	0.2	J	B	0.093	0.3	0.76	J	B	0.093	0.3	1.15			0.093	0.3	12.2			0.093	0.3	0.33	J	B	0.093	0.3	0.9	J	J	0.093	0.3
Iron	300	1100	24.7	J	B	3.04	10	12.3	J	B	3.04	10	16.9	J	B	3.04	10	13.3	J	B	3.04	10	18.7	J	B	3.04	10	16.3	J	B	3.04	10	23.1	J	B	3.04	10
Lead	15	na	0.1	U		0.025	0.1	0.029	J	B	0.025	0.1	0.035	J	B	0.025	0.1	0.1	U		0.025	0.1	0.041	J	B	0.025	0.1	0.1	U		0.025	0.1	0.2	J	J	0.025	0.1
Magnesium	na	na	45100			104	400	32500			52.2	200	33900			52.2	200	18400			52.2	200	36300			52.2	200	27000			52.2	200	30300			52.2	200
Manganese	50	32	15.9			0.27	1	2.87	J	J	0.27	1	35.7			0.27	1	3.69	J	J	0.27	1	3.65	J	J	0.27	1	25.7			0.27	1	2.3	J	J	0.27	1
Nickel	na	30	8.59		J	0.26	1	2.69			0.26	1	35.4			0.26	1	3.88			0.26	1	3.76			0.26	1	2.06		B	0.26	1	2.28		B	0.26	1
Potassium	na	na	5550			9.98	30	1410			9.98	30	2950			9.98	30	1630			9.98	30	4520			9.98	30	1820			9.98	30	1930			9.98	30
Selenium	50	7.8	0.53	J	J	0.11	0.4	0.4	U		0.11	0.4	11.7		J	0.11	0.4	0.4	U		0.11	0.4	0.35	J	J	0.11	0.4	0.16	J	J	0.11	0.4	0.3	J	J	0.11	0.4
Sodium	na	na	77600			160	600	649	J	J	8	30	7760			8	30	2040			8	30	2140			8	30	2000			8	30	13600		J	80	300
Thallium	2	0.016	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.14	J	B	0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2	0.2	U		0.06	0.2
Vanadium	na	7.8	0.12	J	J	0.085	0.3	0.3	U		0.085	0.3	0.4	J	B	0.085	0.3	0.3	U		0.085	0.3	0.27	J	J	0.085	0.3	0.22	J	J	0.085	0.3	0.19	J	B	0.085	0.3
Zinc	5000	470	4.35	J	B	1.31	5	1.9	J	B	1.31	5	3.74	J	B	1.31	5	5.27	J	B	1.31	5	20.7			1.31	5	5.36	J	B	1.31	5	6.09	J	B	1.31	5
Dioxins/Furans (ug/L)	None detected																																					
Misc. (ug/L)																																						
Total Organic Carbon	na	na	55300			3000	10000	2500			300	1000	12100			300	1000	530	J	J	300	1000	2100			300	1000	2800			300	1000	1300		J	300	1000
Chloride	250000	na	12300			50	500	5210			20	200	12500			100	1000	5930			20	200	5770			20	200	2670			10	100	7570			50	500
Nitrate (as N)	10000	5800	4500			20	200	242	J	J	20	200	28	J	J	20	200	1060			20	200	419	J	J	20	200	153	J	J	20	200	2300			20	200
Sulfate	250000	na	195000			2000	20000	240			20	200	53800			200	2000	2930			20	200	46300			400	4000	35300			200	2000	69900			1000	10000
Methane	na	na	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.4	J	J	0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09	1.09	U		0.486	1.09
Ethane	na	na	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22	0.22	U		0.135	0.22
Ethene	na	na	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29	0.818	J	J	0.157	0.29	0.29	U		0.157	0.29	0.29	U		0.157	0.29

*Refer to legend immediately following this table for a list of definitions and table notes.

Table 4-7
Legend

12	J	Shading and black font indicate an MCL exceedance.
12	J	Bold outline indicates a tw-SL exceedance.
12	*12*	Shading in the MDL/MRL columns indicates the MDL exceeds a criterion.

tw-SLs for carcinogenic compounds are shown in red font.
tw-SLs for non-Carcinogenic compounds have been recalculated to an HI of 0.1.
Secondary MCLs were used for aluminum, iron, manganese, silver, and zinc.
MCL Action Levels were used for copper and lead.
MCL Source: 2011 Edition of the Drinking Water Standards and Health Advisories. USEPA. Winter 2011.
tw-SL Source: ORNL Regional Screening Table. November 2011.
µg/L = micrograms per liter (parts per billion).
NA = not applicable.

Lab Q = Lab Data Qualifiers
J = Value <MRL and >MDL and is considered estimated.
U = Analyte not-detected at the method reporting limit.

Val Q = Validation Data Qualifiers
B = Blank contamination. Value detected in sample and associated blank.
J = Estimated concentration.
K = Estimated concentration bias high.
L = Estimated concentration bias low.
UL = Estimated concentration non-detect bias low.

Table 4-8
Summary of Analytes Detected in 2013 Supplemental RFI Groundwater Samples
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Analyte	MCL	tw-SL	# of MCL Exceedances	# of tw-SL Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/L)									
1,1,1-Trichloroethane	200	750	0	0	3	14	0.251	1.66	48MW06
1,1-Dichloroethane	na	2.4	na	1	3	14	0.344	5.86	48MW06
1,1-Dichloroethene	7	26	0	0	1	14	0.301	0.301	48MW06
Acetone	na	1200	na	0	1	14	2.41	2.41	49MW02
Carbon tetrachloride	5	0.39	4	7	7	14	0.664	82.7	48MW2
Chloroform	80	0.19	0	6	6	14	0.193	7.89	48MW3
cis-1,2-Dichloroethene	70	2.8	0	1	3	14	0.373	9.21	48MW06
Methylene chloride	5	4.7	0	0	1	14	2.3	2.3	49MW03
Tetrachloroethene	5	0.072	0	2	2	14	0.255	0.801	48MW06
Toluene	1000	86	0	0	6	14	0.291	2.1	48MW1
Trichloroethene	5	0.44	3	8	8	14	0.934	10.7	48MW3
Total Metals (ug/L)									
Aluminum	50	16000	8	0	14	14	14.7	1730	48MW1
Antimony	6	0.6	0	1	1	14	3.53	3.53	49MW02
Arsenic	10	0.045	0	13	13	14	0.1	1.56	49MW02
Barium	2000	290	0	1	14	14	48.4	408	48MW2
Beryllium	4	1.6	0	0	5	14	0.052	0.099	49MW05
Cadmium	5	0.69	0	0	4	14	0.027	0.16	13MW4
Calcium	na	na	na	na	14	14	42600	102000	48MW06
Chromium	100	1600	0	0	14	14	0.47	31.6	48MW1
Cobalt	na	0.47	na	8	14	14	0.21	4.54	48MW1
Copper	1300	62	0	0	14	14	0.77	15.9	13MW2
Iron	300	1100	5	3	14	14	17.9	2870	48MW1
Lead	15	na	0	na	14	14	0.034	5.27	50MW02
Magnesium	na	na	na	na	14	14	18100	49900	48MW06
Manganese	50	32	3	5	14	14	4.1	67.8	49MW01
Nickel	na	30	na	1	14	14	2.26	40.1	49MW02
Potassium	na	na	na	na	14	14	1000	6040	48MW06
Selenium	50	7.8	0	1	13	14	0.2	10.2	49MW02
Silver	100	7.1	0	0	3	14	0.69	2.45	49MW03
Sodium	na	na	na	na	14	14	673	79800	48MW06
Thallium	2	0.016	0	4	4	14	0.11	0.16	49MW02
Vanadium	na	7.8	na	0	14	14	0.22	3.79	49MW05
Zinc	5000	470	0	0	13	14	1.75	48.7	13MW2
Dissolved Metals (ug/L)									
Aluminum	50	16000	0	0	11	14	2.09	11	49MW02
Antimony	6	0.6	0	1	1	14	3.84	3.84	49MW02
Arsenic	10	0.045	0	9	9	14	0.095	1.5	49MW02
Barium	2000	290	0	1	14	14	43.6	401	48MW2
Calcium	na	na	na	na	14	14	32700	93000	48MW06

Table 4-8
Summary of Analytes Detected in 2013 Supplemental RFI Groundwater Samples
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Analyte	MCL	tw-SL	# of MCL Exceedances	# of tw-SL Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Chromium	100	1600	0	0	14	14	0.4	6.9	13MW2
Cobalt	na	0.47	na	4	14	14	0.077	2.02	49MW02
Copper	1300	62	0	0	14	14	0.2	13	13MW2
Iron	300	1100	0	0	14	14	12.3	24.7	48MW06
Lead	15	na	0	na	10	14	0.029	0.2	50MW02
Magnesium	na	na	na	na	14	14	16000	45100	48MW06
Manganese	50	32	0	1	14	14	0.33	35.7	49MW02
Nickel	na	30	na	1	14	14	1.77	35.4	49MW02
Potassium	na	na	na	na	14	14	892	5550	48MW06
Selenium	50	7.8	0	1	12	14	0.16	11.7	49MW02
Sodium	na	na	na	na	14	14	649	77600	48MW06
Thallium	2	0.016	0	2	2	14	0.14	0.14	13MW5
Vanadium	na	7.8	na	0	11	14	0.11	0.66	13MW2
Zinc	5000	470	0	0	14	14	1.9	45.5	13MW5
Dioxins/furans (ug/L)	***None detected***								
Misc. (ug/L)									
Total Organic Carbon	na	na	na	na	11	14	310	55300	48MW06
Chloride	250000	na	0	na	14	14	2670	12500	49MW02
Nitrate (as N)	10000	5800	0	1	14	14	28	6210	48MW3
Sulfate	250000	na	0	na	14	14	240	195000	48MW06
Methane	na	na	na	na	1	14	1.4	1.4	49MW02
Ethene	na	na	na	na	1	14	0.818	0.818	49MW04

Metals. Twenty-one total metals and 20 dissolved metals were detected in the 14 groundwater samples. Nine total metals (antimony, arsenic, barium, cobalt, iron, manganese, nickel, selenium, and thallium) and eight dissolved metals (antimony, arsenic, barium, cobalt, manganese, nickel, selenium, and thallium) were detected at concentrations above their respective tw-SLs. Three total metals (aluminum, iron, and manganese) were detected at concentrations above their respective MCLs (and tw-SLs).

Dioxin/Furans. Dioxins/furans were not detected in either of the two groundwater samples (50MW02 and duplicate sample 49TM02) analyzed for dioxins/furans.

MNA Parameters. All 14 groundwater samples were analyzed for MNA parameters, including methane, ethane, ethene, chloride, nitrate, sulfate, and TOC to assist in determining the MNA potential in groundwater at the combined study area. A full evaluation of the MNA potential is presented in *Section 4.6*.

Methane. Methane was only detected in one out of the 14 groundwater samples (49MW01) at a concentration of 1.40 µg/L. A tw-SL or MCL does not exist for methane.

Ethane. Ethane was not detected in any of the 14 groundwater samples collected.

Ethene. Ethene was only detected in one out of the 14 groundwater samples (49MW04) at a concentration of 0.818 µg/L. A tw-SL or MCL does not exist for ethene.

Chloride. Chloride was detected in all 14 groundwater samples at concentrations ranging from 2,670 µg/L (49MW05) to 12,500 µg/L (49MW02). Detected concentrations were well below the secondary MCL of 250,000 µg/L. A tw-SL does not exist for chloride.

Nitrate. Nitrate was detected in all 14 groundwater samples at concentrations ranging from 28 µg/L (49MW02) to 6,210 µg/L (49MW03). Detected concentrations were well below the tw-SL of 5,800 µg/L and MCL of 10,000 µg/L.

Sulfate. Sulfate was detected in all 14 groundwater samples at concentrations ranging from 240 µg/L (49MW01) to 195,000 µg/L (48MW06). Detected concentrations were well below the secondary MCL of 250,000 µg/L. A tw-SL does not exist for sulfate.

TOC. TOC was detected in 11 out of the 14 groundwater samples at concentrations ranging from 310 µg/L (48MW2) to 55,300 µg/L (48MW06). A tw-SL or MCL does not exist for TOC.

4.4 Soil Screening Level Comparison

Tables 4-9 and 4-10 present the chemical results from all the investigation soil sampling events for SWMUs 48 and 49, respectively, compared with the (November, 2011) USEPA Regional Soil Screening Level (SSL) soil transfer to groundwater values, using a dilution attenuation factor of 20 (USEPA, 2011a). Only results from the following 21 soil samples that were collected during previous investigations outside the interim measures soil removal area, and from the confirmation soil samples collected from the sidewalls and floor of the excavation, were used for comparison with regional SSLs:

48SB1 (RVFS*1)	48SB09B
48SB1 (RVFS*2)	48SB09C
48SB2 (RVFS*3)	48SB10A
48SB2 (RVFS*4)	48SB10B
48SS1	48SB10C
48SS3	48SC01
48TP4	48SC02
48SB08A	48SC03
48SB08B	48SC04
48SB08C	48SC05
48SB09A	

At SWMU 48, four SVOCs [2,4-DNT; 2,6-DNT; bis(2-ethylhexyl)phthalate; and naphthalene], two explosives (2,4-DNT and nitroglycerin), and two metals (iron and mercury) were detected above their respective SSLs (**Table 4-9**). At SWMU 49, one VOC (ethylbenzene), two PAHs (2-methylnaphthalene and naphthalene), three SVOCs [2-methylnaphthalene, bis(2-ethylhexyl)phthalate, and naphthalene], one pesticide (dieldrin), one PCB (PCB-1232), two explosives (2,4,6-TNT and 2-amino-4,6-DNT), and one metal (selenium) (**Table 4-10**).

While SSL exceedances indicate a theoretical potential for impact to groundwater, empirical evidence in the form of actual groundwater chemical data, soil boring characterization and chemical analyses, soil characteristics/chemistry, and fate and transport analysis offer more concrete evidence of site conditions and potential impact to groundwater.

As discussed in *Section 3.1.2*, groundwater samples were collected from monitoring wells associated with the combined study area in 2007 and analyzed for TCL VOCs, TCL SVOCs, PAHs, TCL pesticides/PCBs, herbicides, explosives, TAL metals, dioxins/furans, and perchlorate. 2007 RFI sample results indicated that five VOCs (1,1-DCA; CT; cis-1,2-DCE; PCE; and TCE), one SVOC [bis(2-ethylhexyl)phthalate], and 15 metals were present above groundwater SLs. As discussed in *Section 3.4*, groundwater samples collected during the 2013 Supplemental RFI were analyzed for TCL VOCs, TAL metals (total and dissolved), dioxins/furans (two samples) and MNA parameters, including methane, ethane, ethene, chloride, nitrate, sulfate, and TOC. Groundwater sample results from the 2013 sampling event indicated that six VOCs (1,1-DCA; CT; chloroform; cis-1,2-DCE; PCE; and TCE), nine total metals (antimony, arsenic, barium, cobalt, iron, manganese, nickel, selenium, and thallium), and eight dissolved metals (antimony, arsenic, barium, cobalt, manganese, nickel, selenium, and thallium) were detected at concentrations above groundwater SLs. Dioxins/furans were not detected in either of the samples collected from well 50MW02.

Based on SSL and groundwater screening results, the only analytes found to exceed both SSLs and groundwater screening criteria at the combined study area were bis(2-ethylhexyl)phthalate, iron, mercury, and selenium. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant, and its presence in soil and groundwater samples collected at the combined study area is not site related or considered a concern in site soil or groundwater. Iron is considered a naturally-occurring macronutrient and not considered to be a concern in media at the site. Mercury was only detected at concentrations above its SSL in 2 of 18 soil samples at SWMU 48 and did not

Table 4-9
SWMU 48 SSL Comparison
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)									
Acetone	na	48000	na	0	1	12	26	26	48SB08A
Methylene chloride	na	24	na	0	1	13	0.002	0.002	48TP4
Toluene	na	11800	na	0	2	13	0.84	1	48SB2 (RVFS*3)
PAHs (ug/kg)									
2-Methylnaphthalene	na	2800	na	0	5	6	0.89	9.6	48SB10A
Anthracene	na	840000	na	0	1	7	0.71	0.71	48SB10A
Benz(a)anthracene	na	200	na	0	2	7	2.9	4.4	48SB08A
Benzo(a)pyrene	na	70	na	0	2	7	2.4	3.6	48SB08A
Benzo(b)fluoranthene	na	700	na	0	2	7	4.7	7.9	48SB08A
Benzo(g,h,i)perylene	na	190000	na	0	2	7	1.4	2.4	48SB08A
Benzo(k)fluoranthene	na	7000	na	0	2	7	1.5	2	48SB08A
Chrysene	na	22000	na	0	2	7	4.6	4.7	48SB08A
Dibenz(a,h)anthracene	na	220	na	0	1	7	0.74	0.74	48SB10A
Fluoranthene	na	1400000	na	0	2	7	6.3	9.8	48SB08A
Fluorene	na	80000	na	0	1	7	1.1	1.1	48SB10A
Indeno(1,2,3-cd)pyrene	na	2400	na	0	2	7	1.6	2.9	48SB08A
Naphthalene	na	9.4	na	0	6	7	1.2	6.7	48SB10A
Phenanthrene	na	190000	na	0	2	7	7.6	18	48SB10A
Pyrene	na	190000	na	0	2	7	8.2	9.5	48SB08A
SVOCs (ug/kg)									
2,4-Dinitrotoluene	na	5.6	na	1	1	12	3200	3200	48SB2 (RVFS*3)
2,6-Dinitrotoluene	na	400	na	1	1	12	1200	1200	48SB2 (RVFS*3)
bis(2-Ethylhexyl)phthalate	na	340	na	1	3	13	1.5	1000	48SB2 (RVFS*3)
Chrysene	na	22000	na	0	1	12	0.086	0.086	48SS1
Di-n-butylphthalate	na	34000	na	0	2	13	190	2900	48SB2 (RVFS*3)
Fluoranthene	na	1400000	na	0	2	12	7.9	11	48SB08A
Naphthalene	na	9.4	na	1	1	12	270	270	48SB2 (RVFS*3)
Phenanthrene	na	190000	na	0	5	12	0.27	200	48SB1 (RVFS*1)
Pyrene	na	190000	na	0	3	12	7.9	300	48SB1 (RVFS*1)
Pesticides (ug/kg)									
4,4'-DDD	na	1320	na	0	2	6	0.347	0.389	48SB08A
4,4'-DDE	na	920	na	0	2	6	0.462	0.525	48SB10A
4,4'-DDT	na	1340	na	0	1	6	2.31	2.31	48SB10A
Endosulfan II	na	na	na	na	1	6	0.418	0.418	48SB10A
Endrin aldehyde	na	na	na	na	1	6	0.55	0.55	48SB10A
Methoxychlor	na	30000	na	0	1	6	0.567	0.567	48SB08A
PCBs (mg/kg)									
PCB-1254	na	0.176	na	0	1	10	0.0769	0.0769	48SB10A

Table 4-9
SWMU 48 SSL Comparison
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (mg/kg)									
2,4-Dinitrotoluene	na	0.0056	na	1	1	17	0.1	0.1	48SC03
Nitroglycerin	na	0.013	na	2	2	15	0.12	0.15	48SB10A
Herbicides (ug/kg)	***None detected***								
Metals (mg/kg)									
Aluminum	40041	460000	1	0	16	16	2940	47900	48TP4
Antimony	na	5.4	na	0	7	18	0.23	1.7	48SC01
Arsenic	15.8	0.026	0	0	13	18	0.6	8.19	48SB1 (RVFS*1)
Barium	209	2400	1	0	18	18	21	572	48SS1
Beryllium	1.02	260	4	0	17	18	0.046	4.98	48SB2 (RVFS*4)
Cadmium	0.69	10.4	1	0	4	18	0.019	0.85	48SC01
Calcium	na	na	na	na	16	16	16.8	240000	48SB1 (RVFS*1)
Chromium	65.3	560000000	0	0	18	18	5.34	38	48SC03
Cobalt	72.3	4.2	0	0	16	16	2.4	58.2	48SB10B
Copper	53.5	440	1	0	16	16	5.39	135	48SB2 (RVFS*3)
Iron	50962	5400	4	4	16	16	8550	81800	48SB10B
Lead	26.8	na	2	na	16	18	4.4	154	48SB2 (RVFS*3)
Magnesium	na	na	na	na	16	16	413	130000	48SB1 (RVFS*1)
Manganese	2543	420	0	0	16	16	39.4	2070	48SB10B
Mercury	0.13	0.66	3	2	13	18	0.0069	2.6	48SB1 (RVFS*1)
Nickel	62.8	400	0	0	18	18	4.3	25.6	48SB2 (RVFS*3)
Potassium	na	na	na	na	16	16	327	2920	48TP4
Selenium	na	8	na	0	4	18	0.15	2.9	48SC04
Silver	na	12	na	0	6	18	0.025	1.2	48SB10B
Sodium	na	na	na	na	12	16	14	2880	48SB2 (RVFS*4)
Thallium	2.11	0.22	0	0	8	18	0.097	0.27	48SB10B
Vanadium	108	1560	0	0	16	16	8.97	96.4	48TP4
Zinc	202	5800	0	0	16	16	18.1	71.3	48SB2 (RVFS*3)
Misc. (mg/kg)									
Total Organic Carbon	na	na	na	na	2	2	975	16700	48SB08A

Table 4-10
SWMU 49 SSL Comparison
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)									
1,1-Dichloroethene	na	1860	na	0	1	19	4.6	4.6	49MW01C
2-Butanone	na	20000	na	0	3	19	6	13	49SB1A
Acetone	na	48000	na	0	10	19	6	1100	49SB1D2
Ethylbenzene	na	30	na	5	6	19	28	1700	49SB1B2
m- & p-Xylene	na	na	na	na	3	18	72	5300	49SB1B2
Methylene chloride	na	24	na	0	7	19	2	11.2	49MW01C
o-Xylene	na	3800	na	0	3	18	86	710	49SB1B2
Toluene	na	11800	na	0	1	19	2.6	2.6	48SB3 (RVFS*6)
Xylenes (total)	na	3800	na	0	1	1	250	250	48SB3 (RVFS*6)
PAHs (ug/kg)									
1-Methylnaphthalene	na	102	na	0	2	7	49.5	65.4	49SS02
2-Methylnaphthalene	na	2800	na	2	6	12	3	12000	49SB02C
Acenaphthene	na	82000	na	0	3	19	15	1100	49SB02C
Acenaphthylene	na	190000	na	0	3	19	7.1	290	49SB02C
Anthracene	na	840000	na	0	4	19	1	480	49SB02C
Benz(a)anthracene	na	200	na	0	3	19	1.5	34	49SB02C
Benzo(a)pyrene	na	70	na	0	3	19	0.66	4.9	49SS01
Benzo(b)fluoranthene	na	700	na	0	4	19	1.8	21.1	49SS03
Benzo(g,h,i)perylene	na	190000	na	0	2	19	1.3	2.9	49SS01
Benzo(k)fluoranthene	na	7000	na	0	2	19	0.96	4.2	49SS01
Chrysene	na	22000	na	0	6	19	1.1	68	49SB02C
Dibenz(a,h)anthracene	na	220	na	0	1	19	2.3	2.3	49SS01
Fluoranthene	na	1400000	na	0	5	19	1.3	120	49SB02C
Fluorene	na	80000	na	0	8	19	1.5	1800	49SB1B
Indeno(1,2,3-cd)pyrene	na	2400	na	0	1	19	3.4	3.4	49SS01
Naphthalene	na	9.4	na	6	9	19	1.7	2500	49SB1B
Phenanthrene	na	190000	na	0	9	19	1.8	4900	49SB02C
Pyrene	na	190000	na	0	4	19	1.1	360	49SB02C
SVOCs (ug/kg)									
2-Methylnaphthalene	na	2800	na	5	5	10	8900	30000	48SB3 (RVFS*6)
Benzoic acid	na	280000	na	0	1	17	210	210	49SS01
bis(2-Ethylhexyl)phthalate	na	340	na	8	9	28	64	40000	48SB5A19
Chrysene	na	22000	na	0	2	14	70	79	48SS4
Dibenzofuran	na	2200	na	0	2	17	1300	1800	49SB1B
Di-n-butylphthalate	na	34000	na	0	3	28	123	1900	48MW3A22
Fluoranthene	na	1400000	na	0	1	14	13	13	49SS01
Fluorene	na	80000	na	0	1	3	8000	8000	48SB3 (RVFS*6)
Naphthalene	na	9.4	na	2	2	14	6000	20000	48SB5A19
Phenanthrene	na	190000	na	0	5	14	13	10000	48SB3 (RVFS*6)
Phenol	na	52000	na	0	1	28	120	120	48MW2A42
Pyrene	na	190000	na	0	2	14	10	800	48SB5A19

Table 4-10
SWMU 49 SSL Comparison
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Pesticides (ug/kg)									
4,4'-DDD	na	1320	na	0	1	10	1.01	1.01	49SS01
4,4'-DDE	na	920	na	0	1	10	0.344	0.344	49SS01
delta-BHC	na	na	na	na	1	10	0.687	0.687	49SB02A
Dieldrin	na	1.22	na	1	1	10	9.45	9.45	49SB02A
Endosulfan II	na	na	na	na	1	10	7.22	7.22	49SB02A
Endosulfan sulfate	na	na	na	na	1	10	6.64	6.64	49SB02A
Endrin aldehyde	na	na	na	na	1	10	0.723	0.723	49SS01
Endrin	na	1360	na	0	1	10	0.757	0.757	49SS01
PCBs (mg/kg)									
PCB-1232	na	0.00148	na	2	2	13	0.708	9.23	49SB02B
PCB-1254	na	0.176	na	0	3	13	0.0109	0.124	49SS03
PCB-1260	na	0.48	na	0	2	13	0.0732	0.152	49SS02
Explosives (mg/kg)									
2,4,6-Trinitrotoluene	na	0.26	na	1	1	16	0.4	0.4	49SB1A
2-amino-4,6-Dinitrotoluene	na	0.46	na	1	1	16	0.6	0.6	49SB1A
Tetryl	na	118	na	0	2	16	0.6	0.72	49SB1A
Herbicides (ug/kg)									
2,4-DB	na	720	na	0	1	9	92.1	92.1	49SS03
Metals (mg/kg)									
Aluminum	40041	460000	0	0	20	20	8650	33700	49SB02C
Antimony	na	5.4	na	0	9	23	0.63	1.5	49SS04
Arsenic	15.8	0.026	0	0	19	23	0.51	8.2	49SS03
Barium	209	2400	0	0	23	23	26.5	119	48SS6
Beryllium	1.02	260	8	0	22	23	0.52	3	49SB1C
Calcium	na	na	na	na	19	20	133	1780	49SB1E
Chromium	65.3	560000000	0	0	23	23	8.7	61.4	49SB1CD
Cobalt	72.3	4.2	0	0	20	20	3.1	29	49SB1F
Copper	53.5	440	0	0	20	20	3	37.5	49SB1F
Iron	50962	5400	0	0	20	20	9060	47700	49SB1CD
Lead	26.8	na	4	na	21	23	3	71.6	49SS02
Magnesium	na	na	na	na	20	20	451	10300	49SB1E
Manganese	2543	420	0	0	20	20	74.5	803	49MW01C
Mercury	0.13	0.66	3	0	12	23	0.034	0.497	48SS4
Nickel	62.8	400	0	0	23	23	5.33	54.1	49SB1D
Potassium	na	na	na	na	20	20	508	3850	49SB02D
Selenium	na	8	na	1	8	23	0.668	9.4	49SS04
Silver	na	12	na	0	3	23	0.0222	0.59	49SB02A
Sodium	na	na	na	na	17	20	16	460	49MW01A
Thallium	2.11	0.22	0	0	10	23	0.067	1.6	49MW01A
Vanadium	108	1560	0	0	20	20	13.9	69.8	49SB02C
Zinc	202	5800	0	0	20	20	10.7	56.5	49SS02

Table 4-10
SWMU 49 SSL Comparison
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Analyte	Background	SSL Transfer	# of Background Exceedances	# of SSL Transfer Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Dioxins/Furans (ng/kg)									
2,3,7,8-TCDF	na	na	na	na	7	7	0.279	1.44	49SS03
2,3,7,8-TCDD	na	5200	na	0	3	7	0.198	0.333	49SS05
1,2,3,7,8-PECDD	na	na	na	na	3	7	1.91	3.72	49SS02
1,2,3,4,7,8-HXCDD	na	na	na	na	4	7	0.588	9	49SS05
1,2,3,6,7,8-HXCDD	na	na	na	na	5	7	0.286	36.5	49SS05
1,2,3,7,8,9-HXCDD	na	na	na	na	5	7	0.272	22.2	49SS02
1,2,3,4,6,7,8-HPCDD	na	na	na	na	7	7	3.37	1110	49SS02
OCDD	na	na	na	na	7	7	295	10000	49SS02
1,2,3,7,8-PECDF	na	na	na	na	4	7	0.168	1.8	49SS03
2,3,4,7,8-PECDF	na	na	na	na	4	7	0.189	1.04	49SS05
1,2,3,4,7,8-HXCDF	na	na	na	na	4	7	0.791	8.47	49SS02
1,2,3,6,7,8-HXCDF	na	na	na	na	4	7	0.343	6.38	49SS02
2,3,4,6,7,8-HXCDF	na	na	na	na	4	7	0.422	8.25	49SS02
1,2,3,7,8,9-HXCDF	na	na	na	na	3	7	0.833	1.3	49SS02
1,2,3,4,6,7,8-HPCDF	na	na	na	na	7	7	0.883	214	49SS02
1,2,3,4,7,8,9-HPCDF	na	na	na	na	4	7	0.718	13.7	49SS02
OCDF	na	na	na	na	7	7	1.9	736	49SS02
TOTAL TCDD	na	na	na	na	4	7	1.2	18.6	49SS03
TOTAL PECDD	na	na	na	na	4	7	1.13	14.4	49SS02
TOTAL HXCDD	na	na	na	na	6	7	1.06	148	49SS02
TOTAL HPCDD	na	na	na	na	7	7	5.79	1670	49SS02
TOTAL TCDF	na	na	na	na	7	7	0.391	17.8	49SS03
TOTAL PECDF	na	na	na	na	4	7	2.94	46.3	49SS02
TOTAL HXCDF	na	na	na	na	7	7	0.228	221	49SS02
TOTAL HPCDF	na	na	na	na	7	7	1.57	719	49SS02
Misc.									
Total Organic Carbon (mg/kg)	na	na	na	na	3	6	8590	36100	48MW2B46
pH	na	na	na	na	2	2	4.81	4.85	49SB02D
Total Petroleum Hydrocarbons (mg/kg)	na	na	na	na	4	12	12	3500	49SB02D

exceed its SSL in any of the 23 samples collected at SWMU 49. The low frequency of SSL exceedances in soil and the single detection of mercury in groundwater at a concentration slightly exceeding the tw-SL indicates that mercury is not vertically migrating and not a concern in media at the sites. Selenium concentrations in soil only exceeded the SSL in one single sample at SWMU 49 and did not exceed the SSL in any soil samples at SWMU 48. Selenium was only detected in one of the 11 groundwater samples at the combined study area and only slightly exceeded the tw-SL (but below the MCL) in the sample it was detected in. Based on the low frequency of detections (FODs) and at concentrations marginally exceeding SLs in both soil and groundwater samples, selenium is not considered a concern in media at the sites.

4.5 Nature and Extent Summary and Conclusions

4.5.1 Soil

4.5.1.1 SWMU 48

The soil at SWMU 48 was initially investigated during the 1991 sampling event and then again in 1995, 1998, and 2002 in support of draft RFIs. A Supplemental Data Investigation was performed in 2010 to augment the 2007 RFI and visibly locate the ash layer within the SWMU 48 trenches via test pitting and characterize the concentrations of explosives in the soil above, within, and below the ash layer. Based upon the findings from the 2010 Supplemental Data Investigation, an interim measures remedial action was performed in the southern portion of the site in 2011 to mitigate the potential threats to human health and the environment that existed from the ash layer and/or grossly-contaminated soil under the ash layer, as well as to mitigate the threat for a potential release of contaminants from ash layer to the groundwater. A total of 3,392.99 tons of non-hazardous and 101.61 tons of hazardous material were removed from the southern trench at SWMU 48. Consistent with the SSL comparison performed in *Section 4.3*, soil results from the 21 soil samples collected during previous investigations outside the removal area and confirmation samples from the interim measures were used for comparison with r-SLs and i-SLs. A summary of the SL comparison of the detected analytical results for these samples at SWMU 48 is presented in **Table 4-11**.

As shown in **Table 4-11**, VOCs, PAHs, SVOCs [with the exception of one explosive (2,4-DNT)], pesticides, and explosives were not detected at concentrations above r-SLs or i-SLs in any of the confirmation soil samples or samples collected outside of the interim measures soil removal area and are not considered a concern in soil at SWMU 48. Herbicides were not detected in any of the samples and, therefore, are not a concern in soil at SWMU 48. The single detection of 2,4-DNT in the SVOC analysis of sample 48SB2 (RVFS*3) at a concentration above the r-SL (but below the i-SL) is isolated and not considered a concern in soil at SWMU 48. PCB-1254 was only detected in a single sample at a concentration slightly exceeding the r-SL (but below the i-SL). No other PCBs were detected in any of 10 samples at SWMU 48; therefore, PCBs are not considered a concern in soil at SWMU 48. Three metals (aluminum, iron, and mercury) were detected at concentrations above background and their respective r-SLs. Iron was the only metal that was detected at concentrations marginally exceeding its i-SL in two soil samples. As previously discussed, iron is a naturally-occurring macronutrient and is not a concern in soil at the site. The low FODs of aluminum and mercury above r-SLs are not a concern in soil at SWMU 48.

Table 4-11
Summary of Analytes Detected in SWMU 48 Soil Samples - 1991 - 2011
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Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)											
Acetone	63000000	6100000	na	0	0	na	1	12	26	26	48SB08A
Methylene chloride	53000	11000	na	0	0	na	1	13	0.002	0.002	48TP4
Toluene	4500000	500000	na	0	0	na	2	13	0.84	1	48SB2 (RVFS*3)
PAHs (ug/kg)											
2-Methylnaphthalene	410000	31000	na	0	0	na	5	6	0.89	9.6	48SB10A
Anthracene	17000000	1700000	na	0	0	na	1	7	0.71	0.71	48SB10A
Benz(a)anthracene	2100	150	na	0	0	na	2	7	2.9	4.4	48SB08A
Benzo(a)pyrene	210	15	na	0	0	na	2	7	2.4	3.6	48SB08A
Benzo(b)fluoranthene	2100	150	na	0	0	na	2	7	4.7	7.9	48SB08A
Benzo(g,h,i)perylene	1700000	170000	na	0	0	na	2	7	1.4	2.4	48SB08A
Benzo(k)fluoranthene	21000	1500	na	0	0	na	2	7	1.5	2	48SB08A
Chrysene	210000	15000	na	0	0	na	2	7	4.6	4.7	48SB08A
Dibenz(a,h)anthracene	210	15	na	0	0	na	1	7	0.74	0.74	48SB10A
Fluoranthene	2200000	230000	na	0	0	na	2	7	6.3	9.8	48SB08A
Fluorene	2200000	230000	na	0	0	na	1	7	1.1	1.1	48SB10A
Indeno(1,2,3-cd)pyrene	2100	150	na	0	0	na	2	7	1.6	2.9	48SB08A
Naphthalene	18000	3600	na	0	0	na	6	7	1.2	6.7	48SB10A
Phenanthrene	1700000	170000	na	0	0	na	2	7	7.6	18	48SB10A
Pyrene	1700000	170000	na	0	0	na	2	7	8.2	9.5	48SB08A
SVOCs (ug/kg)											
2,4-Dinitrotoluene	5500	1600	na	0	1	na	1	12	3200	3200	48SB2 (RVFS*3)
2,6-Dinitrotoluene	62000	6100	na	0	0	na	1	12	1200	1200	48SB2 (RVFS*3)
bis(2-Ethylhexyl)phthalate	120000	35000	na	0	0	na	3	13	1.5	1000	48SB2 (RVFS*3)
Chrysene	210000	15000	na	0	0	na	1	12	0.086	0.086	48SS1
Di-n-butylphthalate	6200000	610000	na	0	0	na	2	13	190	2900	48SB2 (RVFS*3)
Fluoranthene	2200000	230000	na	0	0	na	2	12	7.9	11	48SB08A
Naphthalene	18000	3600	na	0	0	na	1	12	270	270	48SB2 (RVFS*3)
Phenanthrene	1700000	170000	na	0	0	na	5	12	0.27	200	48SB1 (RVFS*1)
Pyrene	1700000	170000	na	0	0	na	3	12	7.9	300	48SB1 (RVFS*1)
Pesticides (ug/kg)											
4,4'-DDD	7200	2000	na	0	0	na	2	6	0.347	0.389	48SB08A
4,4'-DDE	5100	1400	na	0	0	na	2	6	0.462	0.525	48SB10A
4,4'-DDT	7000	1700	na	0	0	na	1	6	2.31	2.31	48SB10A
Endosulfan II	na	na	na	na	na	na	1	6	0.418	0.418	48SB10A
Endrin aldehyde	na	na	na	na	na	na	1	6	0.55	0.55	48SB10A
Methoxychlor	310000	31000	na	0	0	na	1	6	0.567	0.567	48SB08A
PCBs (mg/kg)											
PCB-1254	0.74	0.022	na	0	1	na	1	10	0.0769	0.0769	48SB10A
Explosives (mg/kg)											
2,4-Dinitrotoluene	5.5	1.6	na	0	0	na	1	17	0.1	0.1	48SC03
Nitroglycerin	6.2	0.61	na	0	0	na	2	15	0.12	0.15	48SB10A
Herbicides (ug/kg)	***None detected***										
Metals (mg/kg)											
Aluminum	99000	7700	40041	0	1	1	16	16	2940	47900	48TP4
Antimony	41	3.1	na	0	0	na	7	18	0.23	1.7	48SC01
Arsenic	1.6	0.39	15.8	0	0	0	13	18	0.6	8.19	48SB1 (RVFS*1)
Barium	19000	1500	209	0	0	1	18	18	21	572	48SS1
Beryllium	200	16	1.02	0	0	4	17	18	0.046	4.98	48SB2 (RVFS*4)

Table 4-11
Summary of Analytes Detected in SWMU 48 Soil Samples - 1991 - 2011
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Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Cadmium	80	7	0.69	0	0	1	4	18	0.019	0.85	48SC01
Calcium	na	na	na	na	na	na	16	16	16.8	240000	48SB1 (RVFS*1)
Chromium	150000	12000	65.3	0	0	0	18	18	5.34	38	48SC03
Cobalt	30	2.3	72.3	0	0	0	16	16	2.4	58.2	48SB10B
Copper	4100	310	53.5	0	0	1	16	16	5.39	135	48SB2 (RVFS*3)
Iron	72000	5500	50962	2	4	4	16	16	8550	81800	48SB10B
Lead	800	400	26.8	0	0	2	16	18	4.4	154	48SB2 (RVFS*3)
Magnesium	na	na	na	na	na	na	16	16	413	130000	48SB1 (RVFS*1)
Manganese	2300	180	2543	0	0	0	16	16	39.4	2070	48SB10B
Mercury	4.3	1.0	0.13	0	2	3	13	18	0.0069	2.6	48SB1 (RVFS*1)
Nickel	2000	150	62.8	0	0	0	18	18	4.3	25.6	48SB2 (RVFS*3)
Potassium	na	na	na	na	na	na	16	16	327	2920	48TP4
Selenium	510	39	na	0	0	na	4	18	0.15	2.9	48SC04
Silver	510	39	na	0	0	na	6	18	0.025	1.2	48SB10B
Sodium	na	na	na	na	na	na	12	16	14	2880	48SB2 (RVFS*4)
Thallium	1	0.78	2.11	0	0	0	8	18	0.097	0.27	48SB10B
Vanadium	520	39	108	0	0	0	16	16	8.97	96.4	48TP4
Zinc	31000	2300	202	0	0	0	16	16	18.1	71.3	48SB2 (RVFS*3)
Misc. (mg/kg)											
Total Organic Carbon	na	na	na	na	na	na	2	2	975	16700	48SB08A

The soil results from the excavation limits of the interim measures and soil outside the removal area at SWMU 48 indicate that isolated exceedances of mostly r-SLs exist in soil. The removal of soil during the 2011 interim measures has mitigated the risks to human health and ecological receptors identified in the HHRA (*Section 6.0*) and SLERA (*Section 7.0*).

4.5.1.2 SWMU 49

The soil at SWMU 49 was investigated during the 1991 sampling event and then again in 1994, 1998, and 2002 in support of draft RFIs. In 2007, the soil was investigated in support of completing the RFI. A summary of the SL comparison of the detected analytical results for all soil samples collected at SWMU 49 is presented in **Table 4-12**.

As shown in **Table 4-12**, VOCs, PAHs, pesticides, explosives, herbicides, metals, and dioxins/furans were not detected at concentrations above r-SLs or i-SLs in any of the soil samples collected at the site and are not considered a concern in soil at SWMU 49. The only analytes detected above SLs included two SVOCs [bis(2-ethylhexyl)phthalate and naphthalene], two PCBs (PCB-1232 and PCB-1254), and TPH. Bis(2-ethylhexyl)phthalate was only detected in one soil sample at a concentration marginally above its r-SL (but below its i-SL).

As previously discussed, bis(2-ethylhexyl)phthalate is a common laboratory contaminant that is not site related, and its presence in a single soil sample above its r-SL is not a concern in soil at the site. Naphthalene was detected above its r-SL (but below its i-SL) in one subsurface soil sample and above its i-SL in one other subsurface soil sample (48SB5A19). It should be noted that naphthalene was not detected above its r-SL in any of the 19 soil samples analyzed by the more sensitive PAH analytical method. In addition, naphthalene was not detected in subsurface soil sample 48SB5B37, collected below 48SB5A19, where naphthalene was detected above its i-SL; this indicates that naphthalene is not vertically migrating, and its presence at an elevated concentration in a couple site soil samples is isolated and not considered a concern in site soil.

PCB-1232 was only detected in two subsurface samples collected at depths of 4-6 ft bgs and 8-10 ft bgs from one boring (49SB02). The PCB-1232 concentration in 49SB02B (4-6 ft bgs) was 9.23 mg/kg, and 0.708 mg/kg in 49SB02C (8-10 ft bgs), exceeding the i-SL (0.54 mg/kg) in both samples. A deeper sample was collected from this boring at 17-19 ft bgs (49SB02D) as well as a shallower sample at 0-0.5 ft bgs (49SB02A). PCB-1232 was not detected in either of these samples, indicating that the elevated concentrations of PCB-1232 are limited to these two samples in one single boring and that downward migration of this constituent is not occurring. PCB-1254 was only detected in three out of 13 samples collected at the site. Concentrations of PCB-1254 were found to marginally exceed the r-SL (but below the i-SL) in two surface soil samples (49SS03 and 49SS05). As shown in **Table 4-12**, PCB-1254 was not detected in any subsurface soil samples, indicating that PCBs are not migrating downward at the site.

The most likely source for the PCBs was the oily water that was reportedly disposed of in the SWMU 48/49 area. The low mobility of PCBs appears to have caused the PCBs to bind to soil particles, thus preventing downward migration. As evidenced in **Table 4-4**, groundwater sample results indicate that PCBs were not detected in any of the 11 groundwater samples collected at the combined study area. Therefore, PCBs are not considered a concern in soil or groundwater at SWMUs 48 or 49.

Table 4-12
Summary of Analytes Detected in SWMU 49 Soil - 1991 - 2007
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Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
VOCs (ug/kg)											
1,1-Dichloroethene	110000	24000	na	0	0	na	1	19	4.6	4.6	49MW01C
2-Butanone	20000000	2800000	na	0	0	na	3	19	6	13	49SB1A
Acetone	63000000	6100000	na	0	0	na	10	19	6	1100	49SB1D2
Ethylbenzene	27000	5400	na	0	0	na	6	19	28	1700	49SB1B2
m- & p-Xylene	na	na	na	na	na	na	3	18	72	5300	49SB1B2
Methylene chloride	53000	11000	na	0	0	na	7	19	2	11.2	49MW01C
o-Xylene	300000	69000	na	0	0	na	3	18	86	710	49SB1B2
Toluene	4500000	500000	na	0	0	na	1	19	2.6	2.6	48SB3 (RVFS*6)
Xylenes (total)	270000	63000	na	0	0	na	1	1	250	250	48SB3 (RVFS*6)
PAHs (ug/kg)											
1-Methylnaphthalene	99000	22000	na	0	0	na	2	7	49.5	65.4	49SS02
2-Methylnaphthalene	410000	31000	na	0	0	na	6	12	3	12000	49SB02C
Acenaphthene	3300000	340000	na	0	0	na	3	19	15	1100	49SB02C
Acenaphthylene	1700000	170000	na	0	0	na	3	19	7.1	290	49SB02C
Anthracene	17000000	1700000	na	0	0	na	4	19	1	480	49SB02C
Benz(a)anthracene	2100	150	na	0	0	na	3	19	1.5	34	49SB02C
Benzo(a)pyrene	210	15	na	0	0	na	3	19	0.66	4.9	49SS01
Benzo(b)fluoranthene	2100	150	na	0	0	na	4	19	1.8	21.1	49SS03
Benzo(g,h,i)perylene	1700000	170000	na	0	0	na	2	19	1.3	2.9	49SS01
Benzo(k)fluoranthene	21000	1500	na	0	0	na	2	19	0.96	4.2	49SS01
Chrysene	210000	15000	na	0	0	na	6	19	1.1	68	49SB02C
Dibenz(a,h)anthracene	210	15	na	0	0	na	1	19	2.3	2.3	49SS01
Fluoranthene	2200000	230000	na	0	0	na	5	19	1.3	120	49SB02C
Fluorene	2200000	230000	na	0	0	na	8	19	1.5	1800	49SB1B
Indeno(1,2,3-cd)pyrene	2100	150	na	0	0	na	1	19	3.4	3.4	49SS01
Naphthalene	18000	3600	na	0	0	na	9	19	1.7	2500	49SB1B
Phenanthrene	1700000	170000	na	0	0	na	9	19	1.8	4900	49SB02C
Pyrene	1700000	170000	na	0	0	na	4	19	1.1	360	49SB02C
SVOCs (ug/kg)											
2-Methylnaphthalene	410000	31000	na	0	0	na	5	10	8900	30000	48SB3 (RVFS*6)
Benzoic acid	250000000	24000000	na	0	0	na	1	17	210	210	49SS01
bis(2-Ethylhexyl)phthalate	120000	35000	na	0	1	na	9	28	64	40000	48SB5A19
Chrysene	210000	15000	na	0	0	na	2	14	70	79	48SS4
Dibenzofuran	100000	7800	na	0	0	na	2	17	1300	1800	49SB1B
Di-n-butylphthalate	6200000	610000	na	0	0	na	3	28	123	1900	48MW3A22
Fluoranthene	2200000	230000	na	0	0	na	1	14	13	13	49SS01
Fluorene	2200000	230000	na	0	0	na	1	3	8000	8000	48SB3 (RVFS*6)
Naphthalene	18000	3600	na	1	2	na	2	14	6000	20000	48SB5A19
Phenanthrene	1700000	170000	na	0	0	na	5	14	13	10000	48SB3 (RVFS*6)
Phenol	18000000	1800000	na	0	0	na	1	28	120	120	48MW2A42
Pyrene	1700000	170000	na	0	0	na	2	14	10	800	48SB5A19
Pesticides (ug/kg)											
4,4'-DDD	7200	2000	na	0	0	na	1	10	1.01	1.01	49SS01
4,4'-DDE	5100	1400	na	0	0	na	1	10	0.344	0.344	49SS01
delta-BHC	na	na	na	na	na	na	1	10	0.687	0.687	49SB02A
Dieldrin	110	30	na	0	0	na	1	10	9.45	9.45	49SB02A
Endosulfan II	na	na	na	na	na	na	1	10	7.22	7.22	49SB02A
Endosulfan sulfate	na	na	na	na	na	na	1	10	6.64	6.64	49SB02A

Table 4-12
Summary of Analytes Detected in SWMU 49 Soil - 1991 - 2007
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Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Endrin aldehyde	na	na	na	na	na	na	1	10	0.723	0.723	49SS01
Endrin	18000	1800	na	0	0	na	1	10	0.757	0.757	49SS01
PCBs (mg/kg)											
PCB-1232	0.54	0.14	na	2	2	na	2	13	0.708	9.23	49SB02B
PCB-1254	0.74	0.022	na	0	2	na	3	13	0.0109	0.124	49SS03
PCB-1260	0.74	0.22	na	0	0	na	2	13	0.0732	0.152	49SS02
Explosives (mg/kg)											
2,4,6-Trinitrotoluene	79	19	na	0	0	na	1	16	0.4	0.4	49SB1A
2-amino-4,6-Dinitrotoluene	200	15	na	0	0	na	1	16	0.6	0.6	49SB1A
Tetryl	250	24	na	0	0	na	2	16	0.6	0.72	49SB1A
Herbicides (ug/kg)											
2,4-DB	490000	49000	na	0	0	na	1	9	92.1	92.1	49SS03
Metals (mg/kg)											
Aluminum	99000	7700	40041	0	0	0	20	20	8650	33700	49SB02C
Antimony	41	3.1	na	0	0	na	9	23	0.63	1.5	49SS04
Arsenic	1.6	0.39	15.8	0	0	0	19	23	0.51	8.2	49SS03
Barium	19000	1500	209	0	0	0	23	23	26.5	119	48SS6
Beryllium	200	16	1.02	0	0	8	22	23	0.52	3	49SB1C
Calcium	na	na	na	na	na	na	19	20	133	1780	49SB1E
Chromium	150000	12000	65.3	0	0	0	23	23	8.7	61.4	49SB1CD
Cobalt	30	2.3	72.3	0	0	0	20	20	3.1	29	49SB1F
Copper	4100	310	53.5	0	0	0	20	20	3	37.5	49SB1F
Iron	72000	5500	50962	0	0	0	20	20	9060	47700	49SB1CD
Lead	800	400	26.8	0	0	4	21	23	3	71.6	49SS02
Magnesium	na	na	na	na	na	na	20	20	451	10300	49SB1E
Manganese	2300	180	2543	0	0	0	20	20	74.5	803	49MW01C
Mercury	4.3	1.0	0.13	0	0	3	12	23	0.034	0.497	48SS4
Nickel	2000	150	62.8	0	0	0	23	23	5.33	54.1	49SB1D
Potassium	na	na	na	na	na	na	20	20	508	3850	49SB02D
Selenium	510	39	na	0	0	na	8	23	0.668	9.4	49SS04
Silver	510	39	na	0	0	na	3	23	0.0222	0.59	49SB02A
Sodium	na	na	na	na	na	na	17	20	16	460	49MW01A
Thallium	1	0.78	2.11	0	0	0	10	23	0.067	1.6	49MW01A
Vanadium	520	39	108	0	0	0	20	20	13.9	69.8	49SB02C
Zinc	31000	2300	202	0	0	0	20	20	10.7	56.5	49SS02
Dioxins/Furans (ng/kg)											
2,3,7,8-TCDF	na	na	na	na	na	na	7	7	0.279	1.44	49SS03
2,3,7,8-TCDD	18	4.5	na	0	0	na	3	7	0.198	0.333	49SS05
1,2,3,7,8-PECDD	na	na	na	na	na	na	3	7	1.91	3.72	49SS02
1,2,3,4,7,8-HXCDD	na	na	na	na	na	na	4	7	0.588	9	49SS05
1,2,3,6,7,8-HXCDD	na	na	na	na	na	na	5	7	0.286	36.5	49SS05
1,2,3,7,8,9-HXCDD	na	na	na	na	na	na	5	7	0.272	22.2	49SS02
1,2,3,4,6,7,8-HPCDD	na	na	na	na	na	na	7	7	3.37	1110	49SS02
OCDD	na	na	na	na	na	na	7	7	295	10000	49SS02
1,2,3,7,8-PECDF	na	na	na	na	na	na	4	7	0.168	1.8	49SS03
2,3,4,7,8-PECDF	na	na	na	na	na	na	4	7	0.189	1.04	49SS05
1,2,3,4,7,8-HXCDF	na	na	na	na	na	na	4	7	0.791	8.47	49SS02
1,2,3,6,7,8-HXCDF	na	na	na	na	na	na	4	7	0.343	6.38	49SS02
2,3,4,6,7,8-HXCDF	na	na	na	na	na	na	4	7	0.422	8.25	49SS02
1,2,3,7,8,9-HXCDF	na	na	na	na	na	na	3	7	0.833	1.3	49SS02
1,2,3,4,6,7,8-HPCDF	na	na	na	na	na	na	7	7	0.883	214	49SS02

Table 4-12
Summary of Analytes Detected in SWMU 49 Soil - 1991 - 2007
Page 3 of 3

Analyte	i-SL	r-SL	Background	# of i-SL Exceedances	# of r-SL Exceedances	# of Background Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
1,2,3,4,7,8,9-HPCDF	na	na	na	na	na	na	4	7	0.718	13.7	49SS02
OCDF	na	na	na	na	na	na	7	7	1.9	736	49SS02
TOTAL TCDD	na	na	na	na	na	na	4	7	1.2	18.6	49SS03
TOTAL PECDD	na	na	na	na	na	na	4	7	1.13	14.4	49SS02
TOTAL HXCDD	na	na	na	na	na	na	6	7	1.06	148	49SS02
TOTAL HPCDD	na	na	na	na	na	na	7	7	5.79	1670	49SS02
TOTAL TCDF	na	na	na	na	na	na	7	7	0.391	17.8	49SS03
TOTAL PECDF	na	na	na	na	na	na	4	7	2.94	46.3	49SS02
TOTAL HXCDF	na	na	na	na	na	na	7	7	0.228	221	49SS02
TOTAL HPCDF	na	na	na	na	na	na	7	7	1.57	719	49SS02
Misc.											
Total Organic Carbon (mg/kg)	na	na	na	na	na	na	3	6	8590	36100	48MW2B46
pH	na	na	na	na	na	na	2	2	4.81	4.85	49SB02D
Total Petroleum Hydrocarbons (mg/kg)	100	100	na	3	3	na	4	12	12	3570	48SB5A19

TPH was detected above its SL in three soil samples, 1994 surface sample 48SS5 at a concentration of 335 mg/kg and 1994 subsurface soil sample 48SB5A19 with a concentration of 3,570 mg/kg. Both of these samples were collected near the center of SWMU 49. A third sample (49SB02D) was collected in 2002 from 17 to 19 ft bgs to confirm the previous TPH detections. The TPH concentration in 2002 had decreased slightly from the 1994 concentration to 3,500 mg/kg. Since TPH analyses represent the total of a variety of different compounds, each with differing toxicity, it is difficult to quantify risk based on TPH concentrations. Similar to the potential source for PCBs detected in soil at the site, it is likely that the source for the TPH in soil was the oily water that was reportedly disposed of in the SWMU 48/49 area.

4.5.2 Groundwater

Groundwater for the two sites (SWMUs 48 and 49) is assessed together in this section due to the proximity of the sites and the similarity of constituents in groundwater at the sites. The distribution of elevated soil constituents in groundwater is discussed for SWMUs 48 and 49 at the end of the section. Groundwater data from adjacent SWMUs 50 and 59 have also been included in this analysis.

Groundwater at SWMUs 48, 49, 50, and 59 was investigated during previous investigations in 1996, 1998, and 2006. In 2007, an additional groundwater monitoring well was installed near the center of SWMU 49 to assess impacts to groundwater from the TPH and PCBs detected in site soil. TPH was not analyzed itself; instead, VOCs and SVOCs were analyzed in order to assess the individual chemical components of TPH. Three additional wells were installed in 2007 at SWMU 48 to refine the lateral distribution of VOCs detected in previous investigations and assess the groundwater for impacts from constituents detected in site soil. In addition, three additional wells were installed at SWMUs 50 and 59 in order to assess the groundwater around those sites. Finally, four new wells were installed in 2013 to the south and east of SWMUs 48 and 49 to further delineate the extent of chlorinated solvent contamination in groundwater at the combined site area.

Groundwater results from the 1996 through 2007 investigations indicated that TAL metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and vanadium), VOCs [1,1-DCA; 1,2-DCA (only in 1998); CT; PCE; TCE; methyl chloride (only in 1998 and "B"-flagged)], and one SVOC [bis(2-ethylhexyl)phthalate] were detected above their SLs in site samples.

Bis(2-ethylhexyl)phthalate is a common laboratory contaminant, and its presence in groundwater samples is not considered to be site related. Chloroform was detected at low levels (above the tw-SL, but well below the MCL) during the 1996 and 1998 investigations, and then again during the 2006 investigation; chloroform was not detected in the 2007 samples. Chloroform is a daughter product of the biological degradation of CT, and the presence of chloroform suggests that MNA parameters are aiding in decreasing contaminant mass in groundwater. PAHs, SVOCs, pesticides, PCBs, herbicides, and explosives were not detected in any of the 2007 site groundwater samples.

The most recent round of groundwater sampling in 2013 included 10 existing combined area wells as well as the four newly installed wells; it is the best indication of the current state of groundwater conditions. A summary of all analytes detected in the combined area wells during the 2013 investigation can be found in **Table 4-8**.

The 2013 data indicated that six VOCs (1,1-DCA; CT; chloroform; cis-1,2-DCE; PCE; and TCE) were found above their SLs. The highest VOC concentrations of TCE and CT were found in wells 48MW2 and 48MW3. Vinyl chloride (a breakdown product of TCE and PCE) was analyzed in all 14 samples, but was not detected in any of the samples. As previously discussed, chloroform is a daughter product of CT and indicates that biological degradation of CT is occurring. Similar to chloroform, cis-1,2-DCE is a daughter product of TCE, and its presence in groundwater at the combined area indicates that limited biological degradation of TCE is occurring.

The data from the previous investigations is used to assess concentrations over time in the study area. A comparison in concentration between the 1996 (**Table 2-6**) and 2013 (**Table 4-7**) groundwater investigation results from these sites indicates that the majority of the VOCs are no longer present in these sampled areas and have broken down through natural processes. **Figures 4-1, 4-2, and 4-5** show the progression of the CT groundwater plume over time, between the 1990s and 2013. These figures show that concentrations in the CT plume have: 1) decreased overall, 2) decreased to 1 µg/L surrounding the center of the plume, and 3) decreased at least by one half in the center of the large plume. Also, they show that the plume has spread out slightly to the northwest. As shown on **Figure 4-5**, the CT plume is oval in shape, approximately 250 ft in length (north to south) and 680 ft wide (east to west), and is delineated in all directions. The center of the plume (highest detected concentrations) is located approximately 205 ft southeast of SWMU 49. The upgradient edge of the plume is located approximately 250 ft to the northwest from the center of the plume.

Figures 4-3, **4-4, and 4-6** show the progression of the TCE groundwater plume over time, between the 1990s and 2013. These figures show that concentrations in the TCE plume have decreased to 1 µg/L surrounding the center of the large plume and at least by one half in the center of the plume. Also, they show that the plume has spread out slightly over time. These figures show that these contaminants have been bound in all directions by surrounding wells. As shown on **Figure 4-6**, the TCE plume is triangular in shape, is approximately 560 ft in length (north to south) and 580 ft wide (east to west), and is delineated in all directions. The center of the plume (highest detected concentrations) is located approximately 210 ft southeast of SWMU 49. The upgradient edge of the plume is located approximately 300 ft to the northwest from the center of the plume and extends into SWMU 48.

4.6 MNA Evaluation of SWMU 48/49 Groundwater

MNA is a remedial approach in which physical, chemical, and biological processes occur under favorable conditions, without human interferences to reduce the mass, toxicity, volume, concentration, and mobility of contaminants in soil and groundwater. The physical, chemical, and biological processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization (USEPA, 1998a).

Anaerobic reductive dechlorination is the most prominent mechanism by which chlorinated TCE and CT are biologically degraded. During this process, the chlorinated solvents are used as an electron acceptor, not as a source of carbon, and chlorine atoms are sequentially replaced with hydrogen atoms (protons). TCE yields daughter products cis-1,2-DCE, vinyl chloride, and ethane during this process. CT dechlorination yields chloroform, methylene chloride, chloromethane, and then finally, methane. A common observation is that TCE and CT are reductively dechlorinated under relatively mild nitrate-reducing conditions; whereas, ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project Maps\SWMU_48_49_RFI\RFAAP_Fig4-1_SWMU48_49_1990s_CTC_GW_Plume.mxd (8/7/2013)

LEGEND

- Monitoring Well
- Dirt Road
- Paved Road
- Fence
- 10 ft Contour Line
- Carbon Tetrachloride Isopleth
- Inferred Carbon Tetrachloride Isopleth
- SWMU 48 and SWMU 49 Boundaries
- Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Isopleth concentrations are in ug/L.
3) SWMU 13 and 51 data is from the 1992 RFI (Dames & Moore, 1992). This was the only available data from this time period.

Scale:
0 125 250 500
Feet

U.S. Army Corps of Engineers

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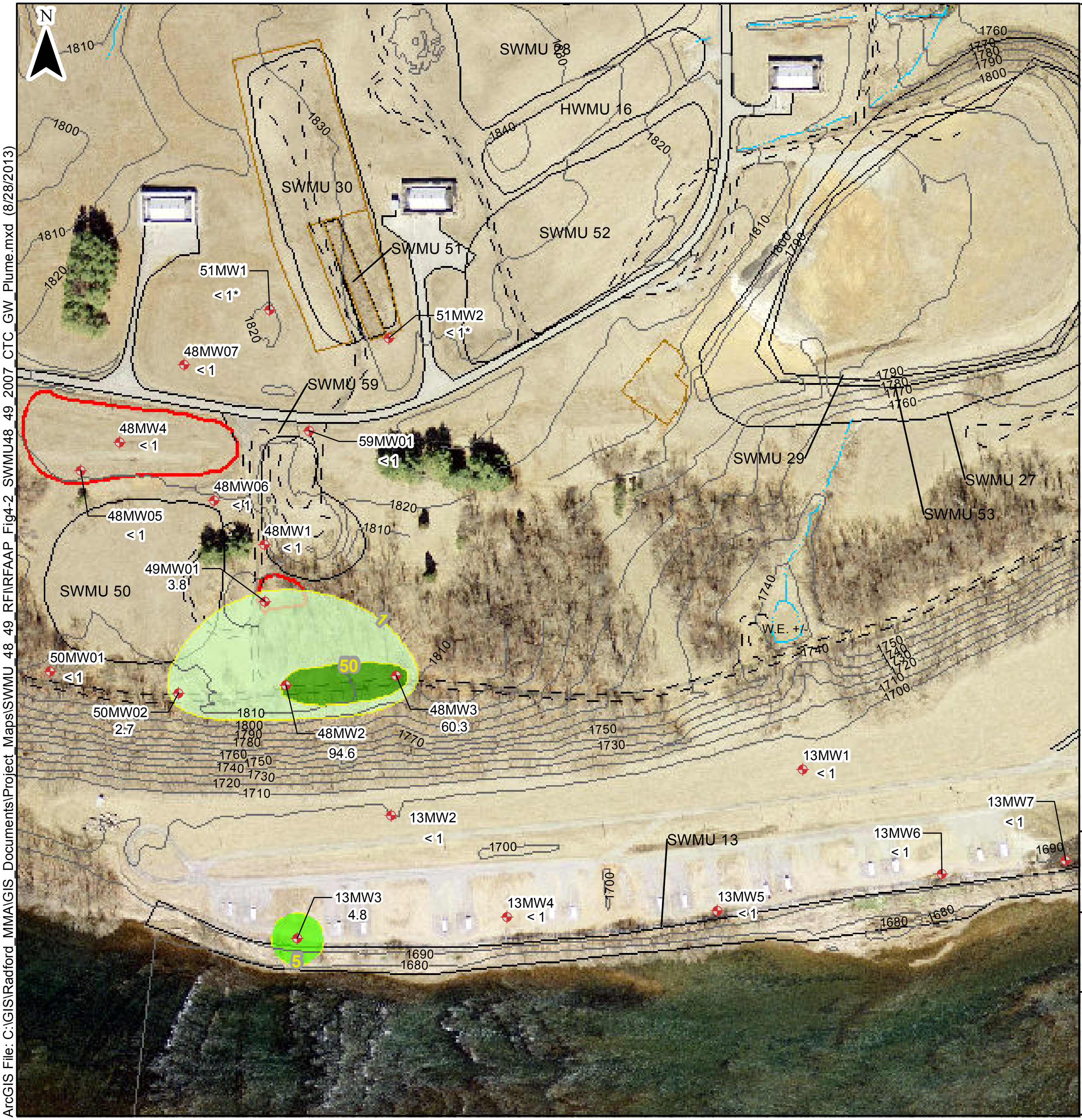
FIGURE 4-1
1992 and 1995 Carbon Tetrachloride Isopleth Map
Radford Army Ammunition Plant,
Radford, VA



LEGEND

- ⌖ Monitoring Well
- – – – Dirt Road
- —— Paved Road
- —— Fence
- —— 10 ft Contour Line
- ▭ Carbon Tetrachloride Isopleth
- ⬚ Inferred Carbon Tetrachloride Isopleth
- 🟥 SWMU 48 and SWMU 59 Boundaries
- ▭ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Isopleth concentrations are in ug/L.
3) Sample results obtained in 2007.
4) * = Last sampled 2006. All prior concentrations were < 1 ug/L.

Scale:
0 125 250 500
Feet

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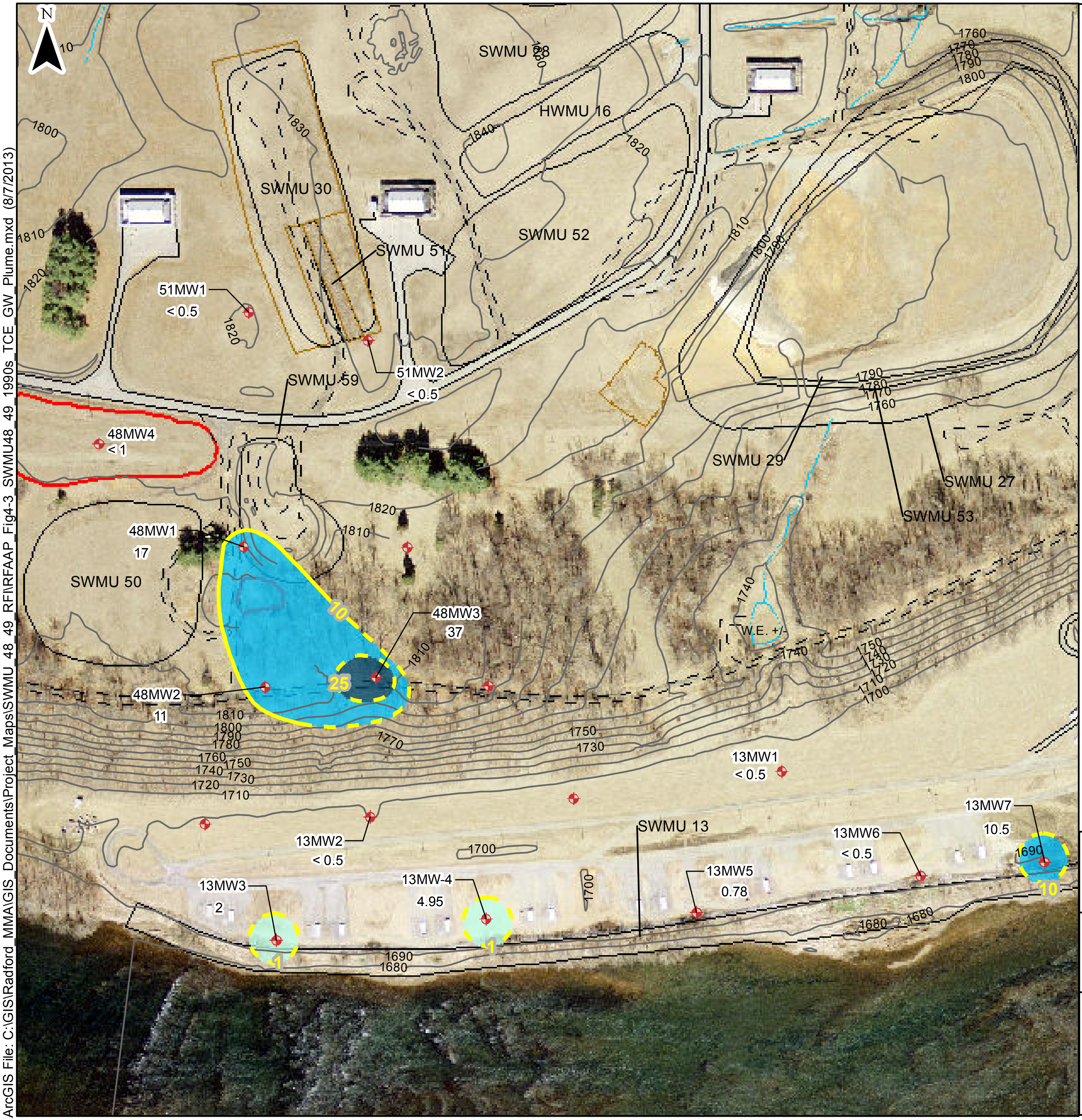
FIGURE 4-2

2007 Carbon Tetrachloride Isopleth Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project Maps\SWMU_48_49_RFI\RFAAP_Fig4-2_SWMU48_49_2007_CTC_GW_Plume.mxd (8/28/2013)



LEGEND

⊕ Monitoring Well

- - - Dirt Road

— Paved Road

— Fence

— 10 ft Contour Line

☐ Trichloroethene Isopleth

☐ Inferred Trichloroethene Isopleth

🟥 SWMU 48 and SWMU 49 Boundaries

☐ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Isopleth concentrations are in ug/L.
3) SWMU 13 and 51 data is from the 1992 RFI (Dames & Moore, 1992). This was the only data from this time period.

Scale:
0 125 250 500
Feet

U.S. Army Corps of Engineers

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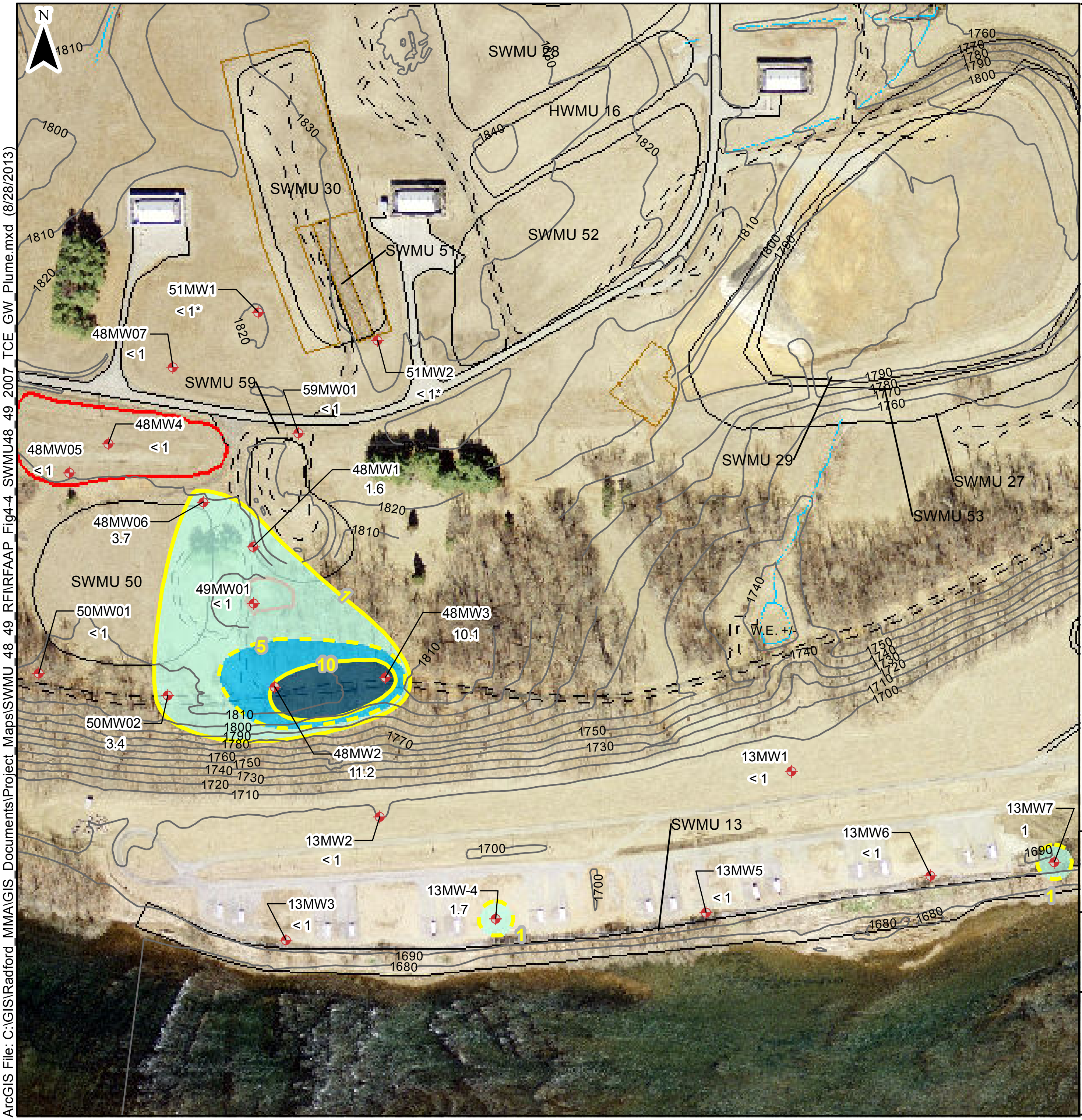
Belcamp, Maryland 21017

FIGURE 4-3

1992 and 1995 Trichloroethene Isopleth Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig4-3_SWMU48_49_1990s_TCE_GW_Plume.mxd (8/7/2013)



ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project Maps\SWMU_48_49_RFI\RFAAP_Fig4-4_SWMU48_49_2007_TCE_GW_Plume.mxd (8/28/2013)

LEGEND

⌖	Monitoring Well
– – –	Dirt Road
———	Paved Road
———	Fence
———	10 ft Contour Line
▭	Trichloroethene Isopleth
▭	Inferred Trichloroethene Isopleth
▭	SWMU 48 and SWMU 49 Boundaries
▭	Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Isopleth concentrations are in ug/L.
3) Sample results obtained in 2007.
4) * = Last sampled 2006. All prior concentrations were < 1 ug/L.

Scale:

0 125 250 500 Feet

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FIGURE 4-4

2007 Trichloroethene Isopleth Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project_Maps\SWMU_48_49_RFI\RFAAP_Fig4-5_SWMU48_49_2013_CTC_GW_Plume.mxd (8/28/2013)

LEGEND

⊕ Monitoring Well

— Fence

- - - Dirt Road

— Paved Road

— 10 ft Contour Line

🟨 Carbon Tetrachloride Isopleth

▭ Inferred Carbon Tetrachloride Isopleth

🟥 SWMU 48 and 49 Boundaries

▭ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Isopleth concentrations are in ug/L.
3) Sample results obtained in 2013.
4) * = Last sampled 2006. All prior concentrations were < 1 ug/L.

Scale:
0 125 250 500
Feet

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FIGURE 4-5

2013 Carbon Tetrachloride Isopleth Map

Radford Army Ammunition Plant,
Radford, VA

ArcGIS File: C:\GIS\Radford_MMA\GIS_Documents\Project Maps\SWMU_48_49_RFI\RFAAP_Fig4-6_SWMU48_49_2013_TCE_GW_Plume.mxd (8/28/2013)

LEGEND

- ⊕ Monitoring Well
- — Fence
- - - Dirt Road
- — Paved Road
- — 10 ft Contour Line
- ▢ Trichloroethene Isopleth
- ▢ Inferred Trichloroethene Isopleth
- ▢ SWMU 48 and 49 Boundaries
- ▢ Other SWMU Boundary

Notes:
1) Aerial photo, dated 2005, was obtained from Montgomery County, VA Planning & GIS Services.
2) Isopleth concentrations are in ug/L.
3) Sample results obtained in 2013.
4) * = Last sampled 2006. All prior concentrations were < 1 ug/L.

Scale:
0 125 250 500 Feet

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FIGURE 4-6

2013 Trichloroethene Isopleth Map

Radford Army Ammunition Plant,
Radford, VA

cis-1,2-DCE, vinyl chloride, and chloroform require increasingly stronger sulfate-reducing conditions to be dechlorinated.

Analytical results from multiple groundwater sampling events at the combined study area were evaluated for qualitative indications of natural attenuation processes that may reduce the levels of TCE and CT. The following sections present the results as they pertain to the lines of evidence used to demonstrate the potential for MNA.

4.6.1 First Line of Evidence: Occurrence of Contaminants

The first line of evidence consists of evaluating contaminant and daughter product concentrations in monitoring wells over time. As previously discussed, 14 combined study area wells were sampled during the 2013 Supplemental Investigation to further delineate the extent of chlorinated solvents in groundwater in the SWMU 48/49 area. As shown in **Table 4-7**, TCE and CT were detected above the MCL of 5 µg/L in five of the 14 site wells. A discussion of the results and concentrations over time is presented below.

TCE. Concentrations of TCE above the MCL of 5 µg/L were observed in three wells (48MW2, 48MW3, and 48MW06) during the 2013 investigation. At 48MW2, TCE concentrations have fluctuated between the 1996 and 2013 investigations, and the daughter products cis-1,2-DCE, vinyl chloride, or ethene have been observed. During this time, TCE concentrations have fluctuated from 11 µg/L in 1995 to 3 µg/L in 2006 and then to 9.75 µg/L in 2013; however, an overall decrease in TCE concentrations has been observed (**Figure 4-7**). At monitoring well 48MW3, a large decrease in TCE concentrations has been observed (**Figure 4-8**); concentrations have decreased from 37 µg/L in 1995 to 10.7 µg/L in 2013. Although TCE levels have decreased, between 2007 and 2013, no significant decrease has been observed, and the daughter products cis-1,2-DCE, vinyl chloride, or ethene have not been observed. The data suggests that MNA processes have led to lower TCE levels, although limited decreases have occurred since 2006. At monitoring well 48MW06, TCE levels have slightly increased from 3.7 µg/L in 2007 to 6.25 µg/L in 2013. Although there was an increase in TCE, the daughter product cis-1,2-DCE was also present and increased from 2.9 µg/L to 9.21 µg/L, indicating that limited biological degradation is occurring. Neither vinyl chloride nor ethene has been observed at this well.

CT. Concentrations of CT were detected above the MCL of 5 µg/L in four wells (48MW2, 48MW3, 49MW02, and 13MW3) during the 2013 investigation. At 48MW2, CT concentrations have fluctuated between 1995 and 2013, and the daughter product chloroform has been observed. The more reduced daughter products dichloromethane and chloromethane were not observed during the sampling events. During this time, CT has fluctuated from 92 µg/L in 1995 to 29.2 µg/L in 2006 and then to 82.7 µg/L in 2013 (**Figure 4-9**). During the same time, the biological degradation product chloroform has remained at approximately 6.0 µg/L. At monitoring well 48MW3, CT concentrations have decreased from 100 µg/L in 1995 to 73.1 µg/L in 2013; however, a slight increase was observed from 60.3 µg/L to 73.1 µg/L between 2007 and 2013 (**Figure 4-10**). Between 1995 and 2013, the degradation daughter product chloroform has been present at 48MW3 and has also decreased from 30 µg/L to 7.89 µg/L. This observed decrease in concentration of CT and the presence of chloroform suggest that MNA parameters are aiding in decreasing contaminant mass in the groundwater. In 2013, groundwater sample results from 49MW02 indicated that CT was detected at a concentration of 5.36 µg/L and was the only analyte detected above its MCL (5 µg/L).

Figure 4-7
48MW2
Chorinated Ethene Concentrations

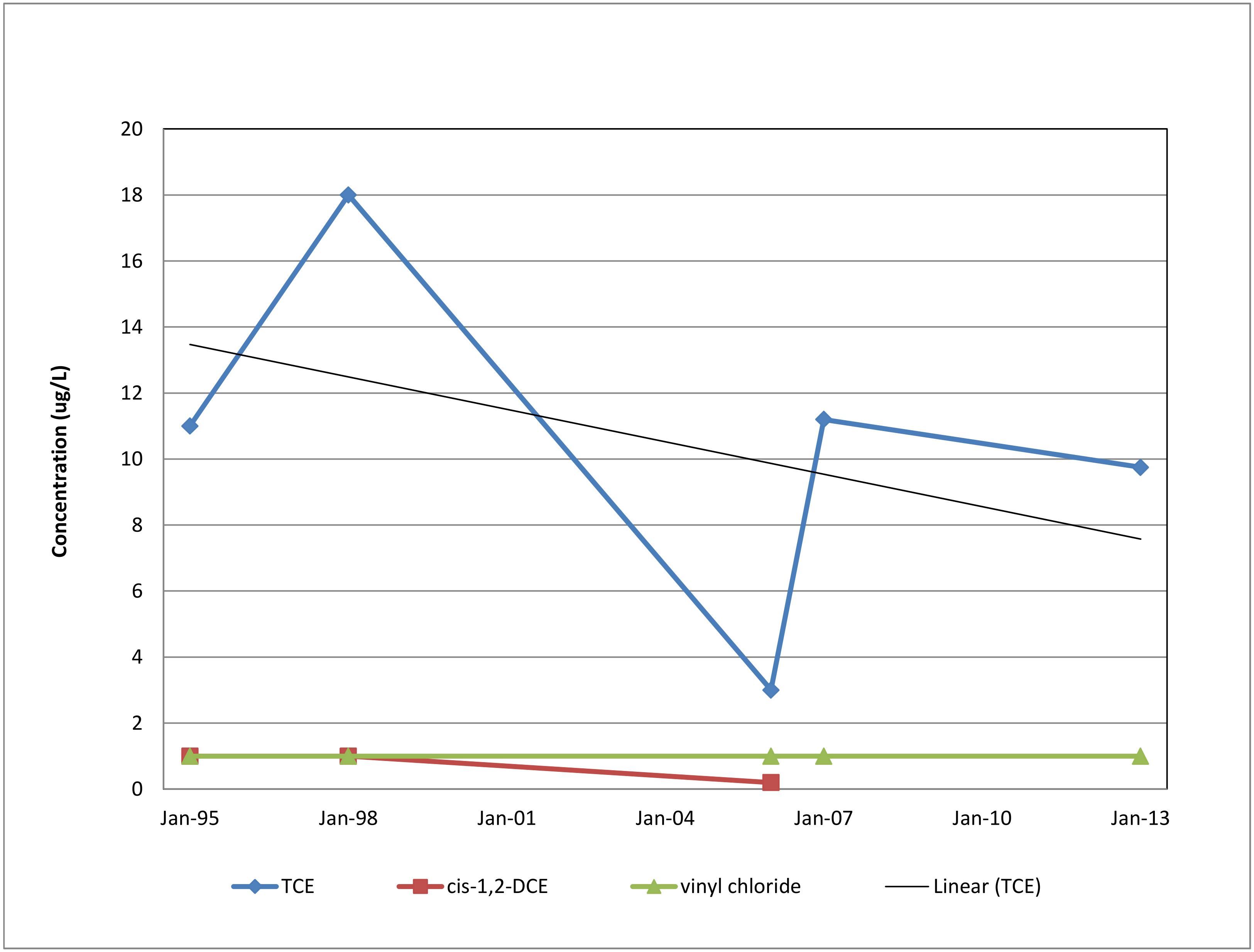


Figure 4-8
48MW3
Chlorinated Ethene Concentrations

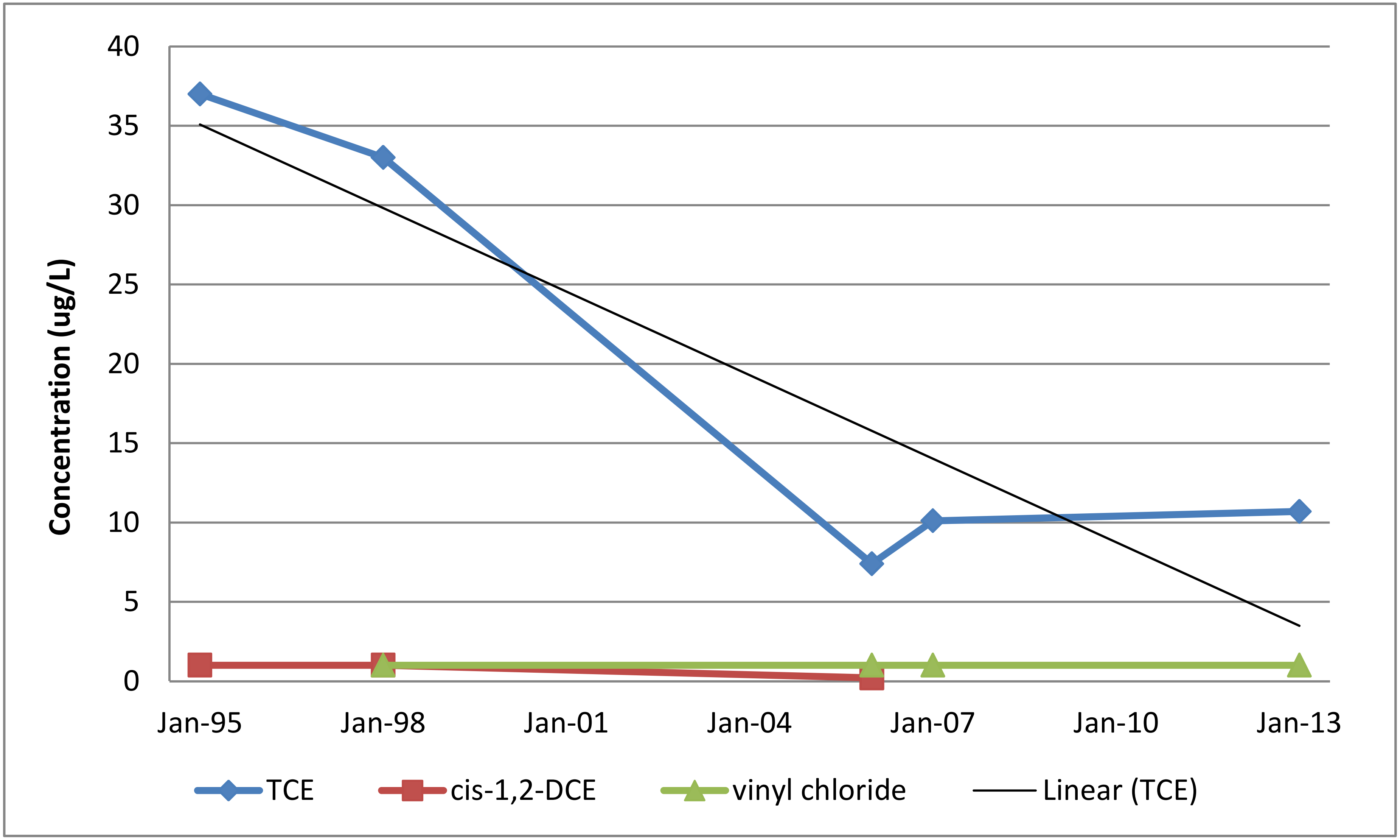


Figure 4-9
48MW2
Carbon Tetrachloride and Daughter Product Concentrations

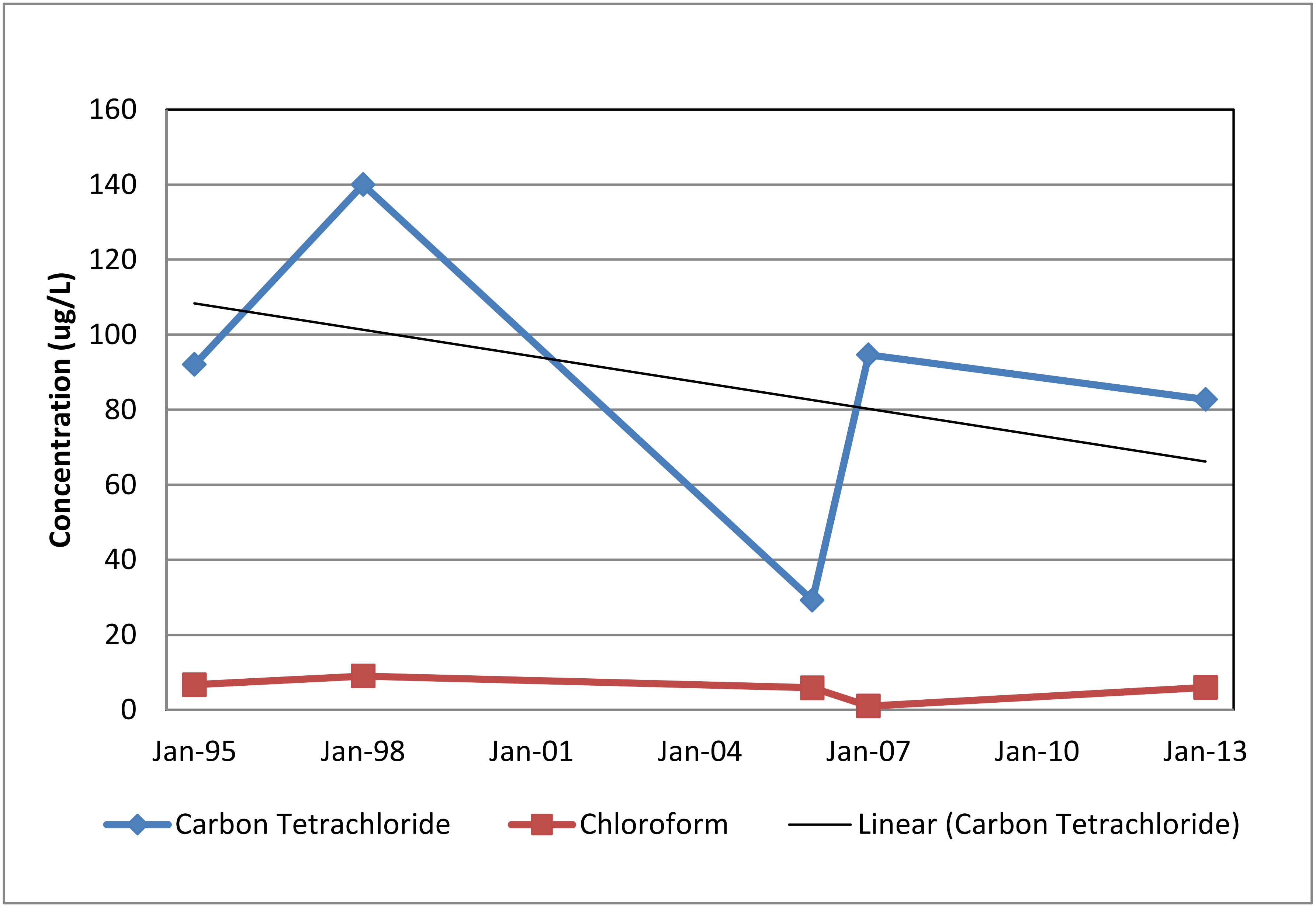
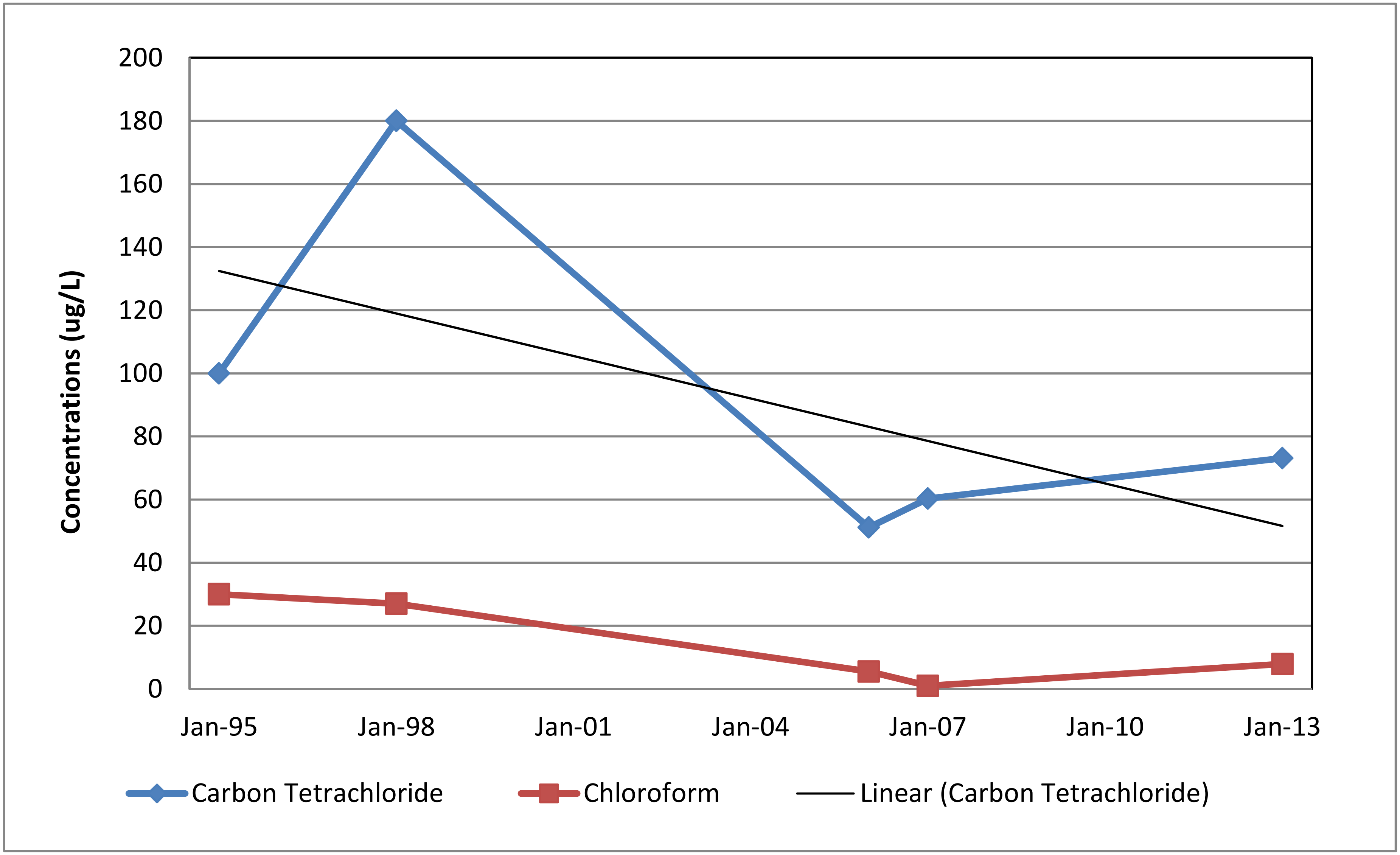


Figure 4-10
48MW3
Carbon Tetrachloride and Daughter Product Concentrations



The daughter product chloroform was also detected at 7.79 µg/L in the sample, suggesting that limited biological degradation is occurring. At well 13MW3, CT has fluctuated from 2 µg/L to 10.5 µg/L to 5.63 µg/L between 1995 and 2013. Chloroform was detected in well 13MW3 during the 2013 investigation at a concentration of 0.453 µg/L, indicating that biological degradation may also be occurring in this area.

4.6.2 Second Line of Evidence: Geochemical Conditions

Respiratory substrates are used preferentially during microbial metabolism based on the amount of energy that can be derived from each of them. Respiratory substrates are used in the following order:

$$O_2 > NO_3^- > Fe^{+3} > ClO_4 > SO_4^{-2} > CO_2$$

Geochemical water quality parameters [dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, and conductivity] were measured in the field during the 2013 groundwater sampling event. The microbial degradation of TCE and CT primarily occur under sulfate-reducing conditions. These geochemical water quality parameters, with respect to the potential for biodegradation in the groundwater at the combined study area, are discussed below.

DO. The preferred terminal electron acceptor during aerobic microbial respiration is oxygen. DO is measured to determine whether the groundwater is under aerobic or anaerobic conditions. Average DO values less than 1 mg/L are tolerable of anaerobic microbial activities.

DO levels during the sampling 2013 sampling event ranged from 1.3 to 9.28 mg/L, indicating that aerobic conditions are present at the site. Values higher than 8 mg/L are considered erroneous records given their relative magnitude to oxygen solubility at field temperatures and are not included in this analysis.

ORP. ORP values indicate the groundwater’s reductive potential and are used to confirm the DO measurements in groundwater. ORP values less than +50 millivolts (mV) typically correspond to mildly reducing, anaerobic conditions, while ORP values less than 200 mV correspond to highly reducing, anaerobic conditions. ORP levels during the 2013 sampling event ranged from -185 to 271 mV. Only two wells sampled during the 2013 sampling event had ORP levels below 50 mV, 48MW06 (33 mV) and 49MW02 (-185 mV). This data indicates that primarily aerobic conditions are present at the site and where the elevated levels of contaminants are present.

pH. The pH for optimum microbial activity ranges from 5 to 9 standard units. Microbial activity may decrease at lower pH values. pH levels measured during the 2013 sampling event ranged from 7.0 to 7.87, indicating that groundwater in the combined study area is suitable for microbial activity.

Nitrate. Following oxygen, microorganisms preferentially use nitrate (NO_3-) as a terminal electron acceptor, and levels above 1,000 µg/L may compete with reductive dechlorination. Nitrate levels during the last sampling ranged from 28 to 6,210 µg/L. This data indicates that the elevated nitrate levels may be inhibiting the degradation of contaminants in groundwater at the combined study area.

Ferrous Iron. Ferric iron is reduced to soluble ferrous iron in groundwater where iron-reducing bacteria have been active. An increase in ferrous iron concentrations above 1,000 µg/L is indicative of iron-reducing conditions. Ferrous iron concentrations detected during the 2013 sampling event ranged from 12.3 to 24.7 µg/L. This data indicates that the groundwater is not currently in a redox state that is able to reduce ferric iron, and along with the nitrate data, confirms that the groundwater is not favorable for the biological reduction of TCE and CT.

Sulfate. Biological degradation of TCE and CT actively occurs under sulfate-reducing conditions. Sulfate levels greater than 20,000 µg/L may cause competitive exclusion (USEPA, 1998a). Sulfate concentrations measured in groundwater during the 2013 sampling event ranged from 240 to 195,000 µg/L. At each of the five wells where elevated levels of TCE and/or CT are present, sulfate levels are above 20,000 µg/L, suggesting that sulfate may inhibit the reduction of lower chlorinated compounds like cis-1,2-DCE.

TOC. Organic carbon is a required source of reduced carbon and energy needed to sustain microbial degradation. TOC concentrations greater than 20,000 µg/L are considered adequate to support microbial activity. Available TOC data from the 2013 sampling event ranged from 310 to 55,300 µg/L. The only well where TOC was observed above 20,000 µg/L was at 48MW06 (55,300 µg/L). This data suggests that the combined study area groundwater does not have a sufficient amount of natural organic carbon throughout the site to sustain reductive dechlorination.

4.6.3 MNA Conclusions

Based on contaminant concentrations and biological indicator parameters measured in groundwater at the site, MNA processes including biodegradation, sorption, dilution, dispersion, and chemical stabilization are occurring in groundwater at the combined study area. The data also suggest that the MNA processes are preserving plume stability.

In summary, the following conclusions were made regarding the potential for MNA in groundwater at the combined study area:

- Decreases in TCE and CT concentrations have occurred from 1995 to 2013 and indicate that MNA processes are aiding in the reduction of contaminated concentrations.
- The presence of daughter products cis-1,2-DCE and chloroform suggest that limited biological degradation has occurred, which also may be aiding in removing mass in the groundwater.
- The geochemical parameters, including DO, ORP, anions, and TOC indicate that groundwater conditions are generally aerobic and not favorable for the complete biological reducing of TCE and CT.
- Additional sampling is required to obtain a more complete data set for the evaluation of site characteristics and further analyze contaminant concentrations in the combined study area.

5.0 CONTAMINANT FATE AND TRANSPORT

This section presents a discussion of the fate and transport mechanisms for chemicals of potential concern (COPCs) at SWMUs 48 and 49. Physical and chemical properties of the impacted media and of the contaminant(s) affect the fate and persistence of contamination in the environment (Rosenblatt et al., 1975). A general discussion of the physical properties and mechanisms which may govern the fate of contaminants in the environment, and a discussion of contaminant transport is presented in **Appendix D**. A discussion of the physical and chemical properties affecting soil conditions at SWMUs 48 and 49 is presented as *Section 5.1*.

No constituents were detected at concentrations greater than their respective r-SL in soil samples collected in 2007 at SWMU 49. However, three metals (beryllium, lead, and mercury) were detected above their background levels. A generalized fate and transport discussion for those constituents identified as risk drivers in the HHRA are presented in *Section 5.2*.

5.1 Soil Properties Affecting Fate and Transport

Chemical and physical properties of soil influence the fate and transport of constituents through the environment. Grain size distribution, pH, and TOC are commonly used to assess these chemical and physical characteristics of the soil. A summary of each follows.

Grain Size Distribution. The grain size distribution measures the amount of clay, silt, sand, and gravel in a sample based on the diameter of the material. Soil particles less than 0.002 millimeters are classified as clay and have a very large specific surface area, allowing them a significant capacity to adsorb water and other substances. Clay composition greatly influences soil fertility and the physical conditions of the soil. Clay directly affects the permeability and the plasticity of soil by generally lowering the soil's permeability and increasing the plasticity. Because pores between clay particles are very small and convoluted, movement of both water and air is very slow. Fate and transport of chemical compounds are hindered when passing through soil with a high composition of clay due to clay's ability to adsorb cations and to retain soil moisture. The surface soil at SWMUs 48 and 49 is comprised of fill material. The site soil beneath the fill at SWMU 48 is mostly clay and silt with little sand. The site soil beneath the fill on the eastern side of SWMU 48 and all of SWMU 49 is mostly silt, with some sand and some clay. Therefore, the site soil beneath SWMU 48 has a high percentage of soil and is a low permeability zone where it is more difficult for constituents to pass through the soil. The site soil beneath SWMU 49 has a high percentage of silt and is a higher permeability zone where it is less difficult for constituents to pass through the soil.

The grain size distribution is also used to assess the permeability of soil. Well-sorted sands and gravels have a smaller distribution of grain size and a higher permeability. Poorly sorted, clayey sands and gravels have a large range in grain size and lower permeability because the smaller clay and silt particles fill in the void spaces between the sand and gravel. The soils beneath the fill at SWMUs 48 and 49 were poorly sorted and, therefore, aided in a lower permeability rate.

Soil pH. Soil pH is a measure of acidity or alkalinity and is an important chemical property because it is an indication of soil reaction potential. Soil reaction influences the fate of many pollutants, affecting their breakdown and potential movement. For example, hydrolysis is the reaction of a compound with water. It usually involves the introduction of a hydroxyl (-OH) group into an organic compound, usually at a point of unbalanced charge distribution. The hydrolysis reaction can displace halogens and may be catalyzed by the presence of acids, bases, or metal ions. Therefore, the rate of hydrolysis is pH and metal-ion concentration dependent. The transport of some contaminants is also affected by pH. This is less significant for neutral and slightly polarized organic compounds, which are somewhat affected by pH, but is significant for chemicals that tend to ionize (Lyman et al., 1990). When the pH of the groundwater is approximately 1.0 to 1.5 units above the negative log of the acid dissociation constant (pK_a), adsorption becomes significant, retarding transport rates. pH also affects the rate of biodegradation that may occur at a site. Most bacteria find the optimum pH range to be 6.5 to 7.5 and are not able to survive at pH values greater than 9.5 or below 4.0 (Knox et al., 1993).

Soil at RFAAP generally ranges in pH from slightly less than 4.0 to slightly more than 9.61. A review of pH results during the *Facility-Wide Background Study Report* (IT, 2001) across soil types at the Main Manufacturing Area did not yield outstanding trends. Higher soil pH results were generally associated with limestone and shale parent material (IT, 2001). Surface and subsurface soil samples collected at SWMUs 48 and 49 had pH measurements ranging from 4.81 to 5.52, indicating that the soil at both sites is acidic in nature.

pH groundwater measurements were taken at SWMUs 48 and 49 wells in August 2007. Those measurements ranged between 6.88 and 7.73. This means that the site groundwater has the optimum pH for bacteria to thrive and degradation to occur.

TOC. Organic matter content is expressed as a percentage, by weight, of the soil material that is a composition of plant and animal residues in the soil at various stages of decomposition. Available water capacity and infiltration rate are affected by organic matter content. Sorption and desorption are two major mechanisms affecting the fate of contaminants in the subsurface. Sorption is the process by which a compound is retained onto a solid particle rather than remaining dissolved in solution. The sorption of contaminants to the soil matrix is an important factor affecting their transport in terrestrial environments. Hydrophobic contaminants will accumulate at an interface or partition into a nonpolar phase (e.g., associate with the organic content of the subsurface medium) rather than partition into the water phase. For nonionic organic chemicals and aquifer materials, sorption is largely controlled by the clay and organic carbon content of the soil. The subsurface soil at SWMU 48 is mainly composed of red-brown clay and silt, and the substratum is orange-brown silt with some sand and clay. The subsurface soil at SWMU 49 is composed of orange-brown silt with some sand and clay, and the substratum is orange-brown silt, sand, and gravel. So, there is a large percentage of clay in the soil beneath SWMU 48 and therefore the permeability and sorption is low. In addition, this means that the amount of TOC present in the soil matrix has a large effect on the fate of both organic and inorganic compounds. The degree to which TOC affects the fate of a chemical varies dependent on the properties of the chemical itself. Soil TOC concentrations at SWMUs 48 ranged from 975 to 16,700 mg/kg, and ranged from 8,590 to 36,100 mg/kg at SWMU 49.

5.2 Fate and Transport of Analytes Detected Above Screening Levels

Analytes that were identified by the HHRA as being soil risk drivers at SWMU 48 and were also detected above SSLs in previous investigations was 2,4,6-TNT. 2,4-DNT; 2,6-DNT; and arsenic were also identified by the HHRA as soil risk drivers at SWMU 48, but were never detected above SLs and are, therefore, not considered soil COIs. The only analyte that was identified by the HHRA as being a soil risk driver at SWMU 49 and was also detected above SSLs in a previous investigation was Aroclor 1232. Arsenic and TCDD TE were also identified by the HHRA as soil risk drivers at SWMU 49, but were never detected above SLs and are, therefore, not considered soil COIs. Constituents detected at concentrations above groundwater levels of concern in 2007, included three VOCs (CT, PCE, and TCE), one SVOC [bis(2-ethylhexyl) phthalate], 11 metals (aluminum, antimony, arsenic, barium, cadmium, chromium, iron, lead, manganese, nickel, and vanadium) and one total dioxin/furan (total HXCDD). Of these detections above SLs, only CT, PCE, TCE, bis(2-ethylhexyl)phthalate, and arsenic were also identified as risk drivers in the HHRA for SWMUs 48 and 49 (*Section 6.0*). Additional analytes [cis-1,2-DCE, pentachlorophenol (PCP), and TCDD TE] were identified by the HHRA as being groundwater risk drivers; however, they were not detected above SLs in 2007 and, therefore, are not considered COIs for groundwater or discussed in this section. Specific characteristics of these chemicals of interest are discussed in more detail in the following sections.

5.2.1 VOCs

5.2.1.1 CT

During the 2013 sampling event, CT was detected above both its tw-SL (0.39 µg/L) and MCL (5 µg/L) in four combined study area monitoring wells (13MW3, 48MW2, 48MW3, and 49MW02). Detected concentrations in all 14 wells sampled during the 2013 sampling event ranged from 0.664 to 82.7 µg/L.

CT is a manufactured chemical that does not occur naturally. It is a clear liquid with a sweet smell that can be detected at low levels. It is also called carbon chloride, methane tetrachloride, perchloromethane, tetrachloromethane, or benziform [Agency for Toxic Substances and Disease Registry (ATSDR), 2005].

CT is most often found in the air as a colorless gas. It is not flammable and does not dissolve in water very easily. It was used in the production of refrigeration fluid and propellants for aerosol cans, as a pesticide, as a cleaning fluid and degreasing agent, in fire extinguishers, and in spot removers. Because of its harmful effects, these uses are now banned and it is only used in some industrial applications (ATSDR, 2005).

CT moves very quickly into the air upon release, so most of it is in the air. It evaporates quickly from surface water. Only a small amount sticks to soil particles; the rest evaporates or moves into the groundwater. It is very stable in air (lifetime 30-100 years). It can be broken down or transformed in soil and water within several days. When it does break down, it forms chemicals that can destroy ozone in the upper atmosphere. It does not bioaccumulate in animals. It is unknown if it builds up in plants (ATSDR, 2005).

5.2.1.2 TCE

TCE was detected in 2013 above both its tw-SL (0.44 µg/L) and MCL (5 µg/L) in three combined study area monitoring wells (48MW2, 48MW3, and 48MW06). Detected concentrations in all 14 wells sampled during the 2013 sampling event ranged from 0.934 to 10.7 µg/L.

TCE is an acronym for the compound trichloroethene. It is a nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers (ATSDR, 1997a).

TCE is not thought to occur naturally in the environment. However, it has been found in underground water sources and many surface waters as a result of the manufacture, use, and disposal of the chemical (ATSDR, 1997a).

Under anaerobic conditions, TCE is slowly biodegraded via reductive dechlorination; the extent and rate of degradation is dependent upon the strength of the reducing environment. If released into water, TCE is expected to adsorb to suspended solids and sediment based upon the average Koc. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. TCE is not hydrolyzed by water under normal conditions. However, slow photooxidation in water has been noted (half-life of 10.7 months) (TOXNET, 2013).

5.2.1.3 PCE

PCE was only detected in two of the 14 combined study area wells, 48MW06 and 50MW02, during the 2013 sampling event at concentrations of 0.255 to 0.801 µg/L, respectively. These detected concentrations exceeded its tw-SL (0.072 µg/L), but were well below the MCL (5 µg/L).

PCE is a manufactured chemical used for dry cleaning and metal degreasing. Other names for PCE include perchloroethylene, tetrachloroethene, and tetrachloroethylene. It is a nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell PCE when it is present in the air at a level of 1 part PCE per million parts of air (1 ppm) or more, although some can smell it at even lower levels (ATSDR, 1997b).

5.2.2 SVOCs

5.2.2.1 Bis(2-ethylhexyl)phthalate

SVOCs were not analyzed in the 2013 Supplemental RFI samples. However, in 2007, bis(2-ethylhexyl)phthalate was detected above both its MCL (6 µg/L) and tw-SL (0.071 µg/L) in one groundwater sample (50MW02) at a concentration of 8 µg/L.

Bis(2-ethylhexyl)phthalate is a manufactured chemical that is commonly added to plastics to make them flexible. It is a colorless liquid with almost no odor. Bis(2-ethylhexyl)phthalate is present in plastic products such as wall coverings, tablecloths, floor tiles, furniture upholstery, shower curtains, garden hoses, swimming pool liners, rainwear, baby pants, dolls, some toys, shoes, automobile upholstery and tops, packaging film and sheets, sheathing for wire and cable, medical tubing, and blood storage bags (ATSDR, 2002).

Exposure to bis(2-ethylhexyl)phthalate is generally very low. Increased exposures may come from intravenous fluids delivered through plastic tubing, and from ingesting contaminated foods or water. It is not toxic at the low levels usually present in the environment. In animals, high levels of bis(2-ethylhexyl)phthalate damaged the liver and kidney and affected the ability to reproduce. Bis(2-ethylhexyl)phthalate has been found in at least 733 of the 1,613 National Priorities List sites identified by the USEPA (ATSDR, 2002).

Bis(2-ethylhexyl)phthalate is everywhere in the environment because of its use in plastics, but it does not evaporate easily or dissolve in water easily. It can be released in small amounts to indoor air from plastic materials, coatings, and flooring. It dissolves faster in water if gas, oil, or paint removers are present. Bis(2-ethylhexyl)phthalate attaches strongly to soil particles. In soil or water, bis(2-ethylhexyl)phthalate can be broken down by microorganisms into harmless compounds. Bis(2-ethylhexyl)phthalate does not break down easily when it is deep in the soil or at the bottom of lakes or rivers. It is bioaccumulated in plants, fish, and other animals, but animals high on the food chain are able to break down this SVOC, so tissue levels are usually low (ATSDR, 2002).

5.2.3 Explosives

The only explosive compound that was deemed a soil risk-driver for SWMU 48 by the HHRA as well as being detected above SSLs was 2,4,6-TNT.

5.2.3.1 2,4,6-TNT

2,4,6-TNT was detected above its SLs in two 1998 soil samples. It was detected above both its i-SL and r-SL in sample 48SB7A at a concentration of 935 mg/kg. It was detected above only its r-SL in sample 48SB7B at a concentration of 35.68 mg/kg. However, as discussed previously, migration of TNT from the soil to groundwater has not occurred.

TNT is a munitions compound currently used for commercial and military purposes. The water solubility of TNT is 2 milligrams per liter (mg/L). Therefore, TNT is characterized as being insoluble in water. The vapor pressure of TNT is 1.28 x 10^{-6} millimeters mercury (mm Hg), which indicates that it will not volatilize to the atmosphere. This is further supported by the Henry's law constants, which for TNT is equal to 1.10 x 10^{-8} atm-m^3/mole. The logarithm ($\log_{10}$) of the organic carbon/water partition coefficient (K_{oc}) is 0.43. This value indicates that TNT will not tend to sorb to the organic fraction of soil and will tend to leach into groundwater or surface water runoff. The logarithm of the octanol/water partition coefficient (K_{ow}) is 2.06, which indicates that TNT will partition to the polar water phase instead of sorbing to soil.

TNT can be biotransformed, mineralized, or conjugated into higher molecular weight (MW) complex products. It has been shown that a reductive pathway exists for biotransformation of TNT (McCormick et al., 1976; Carpenter et al., 1978; Kaplan and Kaplan, 1982a-e, 1985; Kaplan et al., 1985; Greene et al., 1985). This pathway has been observed in a number of systems including aqueous, sewage, soil, and compost (Walker and Kaplan, 1992). Under anoxic conditions, one or more of the nitro groups is reduced through nitroso and hydroylamino intermediates to form aminodinitrotoluenes (2-amino-4,6-DNT and 4-amino-2,6-DNT) and diaminonitrotoluenes (2,4-diamino-6-nitrotoluene and 2,6-diamino-4-nitrotoluene). Nitroaromatic compounds such as TNT are usually considered resistant to oxidation by oxygenase enzymes due to the presence of the electron withdrawing nitro groups on the ring.

Carpenter, McCormick, Cornell, and Kaplan (1978) conducted experiments using radiolabeled TNT in an activated sludge system (aggressive, aerobic conditions) and found no indication of aromatic ring cleavage and mineralization of the TNT to carbon dioxide and water. The authors postulated the one reason that TNT metabolites were not capable of subsequent degradation was the formation of polyamides (a general group of polymers) that are resistant to further microbial attack. However, recent laboratory-scale experiments conducted on TNT contaminated soil from Weldon Springs, Missouri, show that aerobic microbiological mineralization of TNT can occur (Bradley and Chapelle, 1995). In addition, studies with fungal systems (*Phanerochaete chrysosporium*) have provided substantive evidence for mineralization of the aromatic ring of TNT (Fernando and Aust, 1991; Lebron et al., 1992). In addition, 2-, 3-, and 4-nitrotoluene have been detected in the effluent from the RFAAP TNT manufacturing plant, thereby indicating that these compounds are associated with the breakdown of TNT. One study demonstrated that the breakdown of TNT by two strains of the bacterium, *Pseudomonas sp.* strain C1S1, as a nitrogen source involved the successive removal of nitro groups to yield 2,4-DNT; 2,6-DNT; 2-nitrotoluene; and toluene (Duque et al., 1993).

Biodegradation is the most probable degradative process that may occur for 2,4,6-TNT in soil at SWMU 51. Research has shown that TNT can be completely biotransformed through a series of successive denitration steps. The presence of breakdown products (2,4-DNT; 2,6-DNT; 1,3-DNB; 2-, 3-, and 4-nitrotoluene; and 4-amino-2,6-DNT) in the area provide evidence that biodegradation is occurring. Complete degradation of these compounds is anticipated.

5.2.4 Metals

During the 2013 sampling event, nine total metals (antimony, arsenic, barium, cobalt, iron, manganese, nickel, selenium, and thallium) and eight dissolved metals (antimony, arsenic, barium, cobalt, manganese, nickel, selenium, and thallium) were detected at concentrations above their respective tw-SLs. Only three total metals (aluminum, iron, and manganese) were detected at concentrations above both their respective MCLs and tw-SLs. Dissolved metals concentrations were below their respective MCLs.

Arsenic was the only metals constituent to also be deemed a groundwater risk driver by the HHRA. Because most metals are indigenous to the earth, they are usually found at varying concentration levels in most environmental media. The majority of the metals are non-toxic while some metals are toxic to human health and the environment. Non-toxic metals such as barium are required for the growth of young animals and plants, while heavy metals such as lead may inhibit their growth. Humans are good examples for both scenarios. Some metals build up in animal tissue (e.g., zinc accumulation in fish) while some metals accumulate in plants (e.g., vanadium).

Trace levels of metals may be released into the atmosphere from the off-gas of open-hearth furnaces in steel mills, metal smelters (e.g., lead) and incinerators. The airborne particulates are present mainly as oxides or in the form of chlorides in some incinerator emissions. Significant coagulation and interaction can occur in the atmosphere between emitted species and ambient particles of both natural and artificial origin. The particulate matter eventually will be removed from the atmosphere by wet or dry deposition and will be dispersed to a wide area of soil, causing soil contamination or damage to plants.

In soil, metal contaminants are dissolved in the soil solution, adsorbed or ion-exchanged on inorganic soil constituents, complexed with soluble soil organic matter, and precipitated as pure or mixed solids. Metals in the soil solution are subject to movement with soil water and may be transported through the vadose zone to groundwater, taken up by plants and aquatic organisms or volatilized. Unlike organic constituents, metals cannot be degraded; however, some metals such as arsenic and chromium can be transformed among various oxidation states altering their mobility and toxicity. Metal contaminants participate in chemical reactions with the solid soil phase. Immobilization of metals by adsorption, ion exchange, complexation and precipitation can prevent the movement of metal contaminants to groundwater. Changes in soil conditions, such as degradation of organic matrices and changes in pH, redox potential or soil solution composition, due to various remediation schemes or to natural weathering processes, also may change metal mobility in soil.

Fate and transportation mechanisms of the metals with concentrations found to exceed r-SLs and background concentrations are discussed in more detail in the following sections.

5.2.4.1 Arsenic

In 2013, total arsenic was detected above its tw-SL (0.045 µg/L) in 13 of the 14 wells sampled with detected concentrations ranging from 0.1 to 1.56 µg/L. Dissolved arsenic was detected above its tw-SL in nine of the 14 wells sampled with detected concentrations ranging from 0.095 to 1.5 µg/L. All detected total and dissolved arsenic concentrations were well below its MCL of 10 µg/L.

Arsenic is a naturally-occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds (ATSDR, 2007).

Inorganic arsenic compounds are mainly used to preserve wood. Copper chromated arsenate (CCA) is used to make "pressure-treated" lumber. CCA is no longer used in the U.S. for residential uses; it is still used in industrial applications. Organic arsenic compounds are used as pesticides, primarily on cotton fields and orchards (ATSDR, 2007).

Arsenic occurs naturally in soil and minerals and may enter the air, water, and land from wind-blown dust and may get into water from runoff and leaching. Arsenic cannot be destroyed in the environment. It can only change its form. Rain and snow remove arsenic dust particles from the air. Many common arsenic compounds can dissolve in water. Most of the arsenic in water will ultimately end up in soil or sediment (ATSDR, 2007).

5.2.5 Polychlorinated Biphenyls

PCBs were not analyzed in any of the 14 groundwater samples collected during the 2013 Supplemental RFI. PCBs were not detected in any of the 11 groundwater samples collected during the 2007 RFI.

5.2.5.1 Arocolor 1254

Aroclor 1254 was the only SWMU 49 soil constituent to be determined a SWMU 49 soil risk driver in the HHRA as well as being detected in samples above its SLs. In 2002, Aroclor 1254 was detected above its SLs in two samples. It was detected above its tw-SL in subsurface sample 49SB02C and then above both its MCL and tw-SL in subsurface sample 49SB02B.

PCBs, which are also known by the trade name "Aroclor," were produced by the partial chlorination of biphenyl in the presence of a catalyst. The production of PCBs in large quantities began in 1929. Prior to 1974, PCBs were used both for nominally closed applications (e.g., capacitor and transformers, and heat transfer and hydraulic fluids) and in open-end applications (e.g., flame retardants, inks, adhesives, microencapsulation of dyes for carbonless duplicating paper, paints, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, surface coatings, wire insulators, and metal coatings) (Durfee, 1976; IARC, 1978; Orris et al., 1986; Safe, 1984; Welsh, 1995). The manufacture of PCBs in the United States ceased in 1977 because of evidence that PCBs were toxic and accumulated in the environment.

PCBs are distinguished by a four-digit code in which the first two digits (e.g., 12) indicate the production process and the second two digits indicate the weight percent of chlorine (e.g., 48).

Thus, Aroclor 1254 is a PCB with an average chlorine content of 54 percent. The water solubility for Aroclor 1254 is 4.1×10^{-2} mg/L. Therefore, this Aroclor is not soluble in water. The vapor pressure of Aroclor 1254 is 4.40×10^{-5} mm Hg. As a result of the low vapor pressure, this PCB will not volatilize to the atmosphere. This point is further supported by the Henry's Law Constant, which for this compound is 2.0×10^{-4} atm-m^3/mole. The log K_{oc} and log K_{ow} values for Aroclor 1254 is 6.33 and 6.94, respectively. The log K_{oc} values indicate that the PCBs will tend to stay bound to the organic fraction of the soil instead of leaching into groundwater or surface water runoff. The log K_{ow} values support this argument indicating that PCBs have a stronger affinity for nonpolar soil particles than a polar water phase.

PCBs are highly immobile. PCBs are very persistent in the environment and are extremely resistant to oxidation and hydrolysis. The properties that made PCBs applicable for industrial use are the same properties that cause it to be persistent in the environment: chemical stability; thermal stability; resistance to hydrolysis by water, alkalis, and acids; and low flammability. Based on the K_{oc} and K_{ow} values, Aroclor 1248 and Aroclor 1254 will tend to remain in soil once released into the environment.

6.0 HUMAN HEALTH RISK ASSESSMENT

This HHRA evaluates the probability and magnitude of potential adverse effects on human health associated with exposure to site-related chemicals in soil and groundwater. The HHRAs were conducted for each of the sites consistent with guidance included in USEPA's *Interim Final Risk Assessment Guidance for Superfund (RAGS)* and other current USEPA/USEPA Region III resources and guidance documents as noted throughout this section and on the RAGS Part D tables provided in **Appendices E-1 and E-2**. Additional information regarding the site background can be found in *Section 2.0*. This HHRA consists of the following six sections:

- **Section 6.1: Data Summary and Selection of COPCs:** Relevant site data are gathered, examined, and discussed. Basic constituent statistics and SLs are summarized. COPCs are identified by comparison to screening criteria as discussed in *Section 6.1.2*.
- **Section 6.2: Exposure Assessment:** Potentially exposed populations (e.g., receptors) and exposure routes are identified, and exposure point concentrations (EPCs) are calculated for COPCs. Standard exposure factors and health-protective assumptions are used to assess the magnitude, frequency, and duration of exposure for each exposure route and intakes are calculated.
- **Section 6.3: Toxicity Assessment:** Toxicity criteria for COPCs are gathered and presented.
- **Section 6.4: Risk Characterization:** Quantitative risks and hazards are estimated and summarized by combining toxicity criteria with intakes for each exposure route.
- **Section 6.5: Uncertainties Analysis:** Uncertainties, "including uncertainties in the physical setting definition for the site, in the models used, in the exposure parameters, and in the toxicity assessment" (USEPA, 1989a) are discussed.
- **Section 6.6: Summary and Conclusions:** The results of the HHRA are summarized.

The tabulated risk assessment results are presented in accordance with USEPA guidance described in *RAGS: Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments)* (USEPA, 2001a). RAGS D requires the risk assessment results to be presented in a series of standardized tables, which are presented in **Appendix E-1** for SWMU 48 and **Appendix E-2** for SWMU 49.

6.1 Data Summary and Selection of COPCs

6.1.1 Data Summary

Table 6-1 identifies the soil and groundwater samples used in the HHRA for SWMUs 48 and 49. The complete data tables for detected analytes for each media are provided in *Section 4.0*. Additional information regarding the data used in the HHRAs is summarized below:

- Though several dioxins are known to be toxic, toxicity criteria are limited to 2,3,7,8-TCDD. Therefore, the HHRA uses the method outlined in Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) (USEPA, 1989b and Van den Berg et al., 2006) to assess risks due to exposure to dioxins and/or furans. Each congener is

Table 6-1
SWMU 48 and SWMU 49
Sample Groupings

SURFACE SOIL[a]			
SWMU 48	48SB08A	48SB10A	48SS3
	48SB09A	48SS1	
TOTAL SOIL[b]			
SWMU 48	48SB08A	48SB09C	48SB10C
	48SB08B	48SB1 (R-1)	48SB2 (R-3)
	48SB08C	48SB1 (R-2)	48SS1
	48SB09A	48SB10A	48SS3
	48SB09B	48SB10B	48TP4
SURFACE SOIL[a]			
SWMU 49	48SS4	49SS01	49SS05
	48SS5	49SS02	49SS05 - Dup
	48SS6	49SS03	
	49SB02A	49SS04	
TOTAL SOIL[b]			
SWMU 49	48SS4	49SS03	49MW01B
	48SS5	49SS04	49SB02B
	48SS6	49SS05	49SB02C
	49SB02A	49SS05 - Dup	49SB1A
	49SS01	49MW01A	
	49SS02	49MW01A - Dup	
GROUNDWATER [c]			
SWMUs 48 & 49	48MW05	48MW1-2D	48MW4
	48MW06	48MW2	49MW01
	48MW07	48MW2-2	50MW01
	48MW4-2	48MW3	50MW02
	48MW1	48MW3 - Dup	59MW01
	48MW1-2	48MW3-2	59MW01 - Dup

(a) Surface soil samples consist of samples collected at depths of 0 to 0.5 feet.

(b) Total soil sample group includes all surface soil and subsurface soil samples from 0 to 15 feet. If soil sample depth straddled the 0 to 15 feet range, then it was also included in the data set for total soil.

(c) Based on proximity, the groundwater sampling group includes wells from SWMUs 48, 49, 50, and 59.

assigned a toxicity equivalent factor (TEF), which corresponds to its toxicity relative to 2,3,7,8-TCDD. Each congener detection is multiplied by its corresponding TEF; the adjusted concentrations are then summed to derive one total 2,3,7,8-TCDD equivalent concentration for each sample. This concentration is then compared with toxicity criteria for 2,3,7,8-TCDD to calculate risks. TEFs are presented and total 2,3,7,8-TCDD equivalents are calculated for surface soil, total soil, and groundwater in **Appendix E-3**.

- If a constituent was measured by two methods, results from the more sensitive analytical method were used. For example, PAHs were analyzed as part of the SVOC method, as well as by a PAH-specific method. Results from the specific method were used.
- J-flagged data (estimated concentration) are considered detections and are used without modification.
- The qualification and validation of the analytical data included a comparison of the site data to corresponding blank (laboratory, equipment rinse, field, and trip) concentration data. If the detected concentration in a site sample was less than ten times (for common laboratory contaminants) or five times (for other compounds) the concentration in the corresponding blank sample, the sample was qualified with a "B." According to USEPA Region III guidance (USEPA, 1995a, 2000b), it cannot be unequivocally stated that the result is not "non-detected" at that concentration. Therefore, B-qualified data are typically eliminated from the data set.
- Rejected results (R-flagged) are not used.
- Data from duplicate sample pairs are averaged and treated as one result. If an analyte is detected in one of the sample pair, one half the detection limit of the non-detect is averaged with the detected result and the result is considered detected.

Additional information regarding specific soil and groundwater samples used in the HHRA is provided in *Sections 6.1.1.1 and 6.1.1.2*.

6.1.1.1 Surface Soil and Total Soil

Soil samples collected during sampling events in 1991, 1994, 1998, and 2002 were used in the initial investigation of SWMU 48. Confirmatory samples were collected after the removal action was completed in 2011. The soil samples used for COPC screening in this HHRA represent soil left in place

The soil samples used for COPC screening of SWMU 49 were collected during sampling events in 1994, 1998, 2002, and 2007. No new data were collected at SWMU 49 as part of the removal action at SWMU 48. As presented in **Table 6-1**, the soil samples for SWMUs 48 and 49 have been divided into surface soil (0 to 0.5 ft bgs) and total (0 to 15 ft bgs). The total soil data grouping was assembled by combining the surface and subsurface soil data sets to address mixing of potential soil contamination during construction or land development activities. A total of five surface soil samples and nine subsurface soil samples (and one duplicate sample) were used in the HHRA for SWMU 48. A total of nine surface soil samples (and one duplicate sample) and five subsurface soil samples (and one duplicate sample) were used in the HHRA for SWMU 49.

6.1.1.2 Groundwater

Groundwater samples collected during sampling events completed in 1998 and 2007 were used for the COPC screening. A total of 16 samples and two duplicate samples were collected. These locations are listed in **Table 6-1**.

6.1.2 Identification of COPCs

COPCs were identified for the sites by comparing the maximum detected concentration (MDC) with the following SLs for each media: USEPA Residential-Regional Screening Levels (RSLs) (surface soil and total soil) and USEPA tw-RSLs (groundwater) as presented in the November 2011 USEPA RSLs Tables (USEPA, 2011a). In accordance with USEPA Region III guidance, RSLs for non-carcinogenic chemicals were adjusted downward to a hazard quotient (HQ) of 0.1 to ensure that chemicals with additive effects were not prematurely eliminated during screening. Although current and future land uses at SWMUs 48 and 49 are most likely to be industrial in nature, Residential-RSLs (rather than industrial) were used for comparisons with soil concentrations. Because the residential scenario was evaluated for this HHRA, Residential-RSLs were used to screen chemicals in soil as a conservative measure. In addition, the lead action level of 400 mg/kg for residential receptors was used in the COPC identification since toxicity criteria were not available for lead (USEPA, 1994a). The action level for drinking water (15 µg/L) was used to screen lead in groundwater.

The maximum concentrations of the four essential human nutrients that do not have RSLs (i.e., calcium, magnesium, potassium, and sodium) were compared with dietary Allowable Daily Intakes. The essential nutrients calcium, magnesium, potassium, and sodium were eliminated as COPCs. Although iron is also an essential nutrient, there is an RSL available for iron. If iron concentrations in soil or water resulted in an HQ of 1.0 or greater, a “margin of exposure” evaluation was also performed. Risks from exposure to iron were characterized by comparing estimated iron intake to the Recommended Daily Allowance (RDA) and concentrations known to cause effects in children (USEPA, 1996a).

Analytes detected at a maximum concentration greater than the corresponding adjusted RBC or screening values identified above for nutrients and lead were selected as COPCs. Analytes for which no screening criteria exist were also selected as COPCs. COPC screening tables for each area are presented in **Appendix E-1, Tables E.1-2** (COPC Determination Detects-Surface Soil), **E.1-4** (COPC Determination Detects-Total Soil), and **E.1-6** (COPC Determination Detects-Groundwater) for SWMU 48, and **Appendix E-2, Tables E.2-2** (COPC Determination Detects-Surface Soil), **E.2-4** (COPC Determination Detects-Total Soil), and **E.2-6** (COPC Determination Detects-Groundwater) for SWMU 49. The COPCs selected for each medium are summarized in **Table 6-2** for SWMU 48 and **Table 6-3** for SWMU 49.

Similarly, the reporting limits for those constituents that were not detected were compared with RSLs for each medium. Chemicals that were not detected in at least one medium have not been included in the HHRA. The reporting limits for the non-detected constituents were screened against the RSLs to ensure that the range of reporting limits was generally low enough to detect constituents above RSLs. The maximum reporting limits for these constituents were compared with RSLs. The results of these comparisons are shown in **Appendix E-1, Tables E.1-3** (Non-Detect Screening-Surface Soil), **E.1-5** (Non-Detect Screening-Total Soil), and **E.1-7** (Non-Detect Screening-Groundwater) and **Appendix E-2, Tables E.2-3** (Non-Detect Screening-

Table 6-2
Summary of Chemicals of Potential Concern at SWMU 48

Chemical (a)	Surface Soil	Total Soil	Groundwater
Organics			
bis(2-Ethylhexyl)phthalate			X
Carbon Tetrachloride			X
1,1-Dichloroethane			X
1,2-Dichloroethane			X
cis-1,2-Dichloroethene			X
2,4-Dinitrotoluene		X	
2,6-Dinitrotoluene		X	
Pentachlorophenol			X
TCDD-Toxicity Equivalent	X	X	X
Tetrachloroethene			X
Trichloroethene			X
Inorganics			
Aluminum	X	X	X
Arsenic	X	X	X
Barium			X
Beryllium			X
Cadmium			X
Calcium			X
Chromium	X	X	X
Cobalt	X	X	X
Copper			X
Iron	X	X	X
Lead			X
Magnesium			X
Manganese	X	X	X
Mercury		X	
Nickel			X
Selenium			X
Silver			X
Sodium			X
Thallium	X	X	X
Vanadium		X	X

(a) Chemicals detected in all media at SWMU 48.
X = Selected as a COPC in this media.

Table 6-3
Summary of Chemicals of Potential Concern at SWMU 49

Chemical (a)	Surface Soil	Total Soil	Groundwater
Organics			
Aroclor 1232		X	
Aroclor 1254	X	X	
bis(2-Ethylhexyl)phthalate			X
Carbon Tetrachloride			X
1,1-Dichloroethane			X
1,2-Dichloroethane			X
cis-1,2-Dichloroethene			X
Pentachlorophenol			X
TCDD-Toxicity Equivalent	X	X	X
Tetrachloroethene			X
Trichloroethene			X
Inorganics			
Aluminum	X	X	X
Arsenic	X	X	X
Barium			X
Beryllium			X
Cadmium			X
Calcium			X
Chromium	X	X	X
Cobalt	X	X	X
Copper			X
Iron	X	X	X
Lead			X
Magnesium			X
Manganese	X	X	X
Nickel			X
Selenium			X
Silver			X
Sodium			X
Thallium	X	X	X
Vanadium	X	X	X

a) Chemicals detected in all media at SWMU 49.
X = Selected as a COPC in this media.

Surface Soil), **E.2-5** (Non-Detect Screening-Total Soil), and **E.2-7** (Non-Detect Screening-Groundwater). Detected constituents identified as COPCs were carried through the quantitative risk assessment. The reporting limits for constituents that were not detected in surface soil, total soil, or groundwater are evaluated with respect to their screening criteria and discussed in the uncertainty section (Section 6.5.2).

6.2 Exposure Assessment

The objective of the exposure assessment is to estimate "the type and magnitude of exposures to chemicals of potential concern" (USEPA, 1989a). When combined with chemical-specific toxicity information (summarized in the toxicity assessment), these exposures produce estimations of potential risks.

6.2.1 Conceptual Site Model/Receptor Characterization

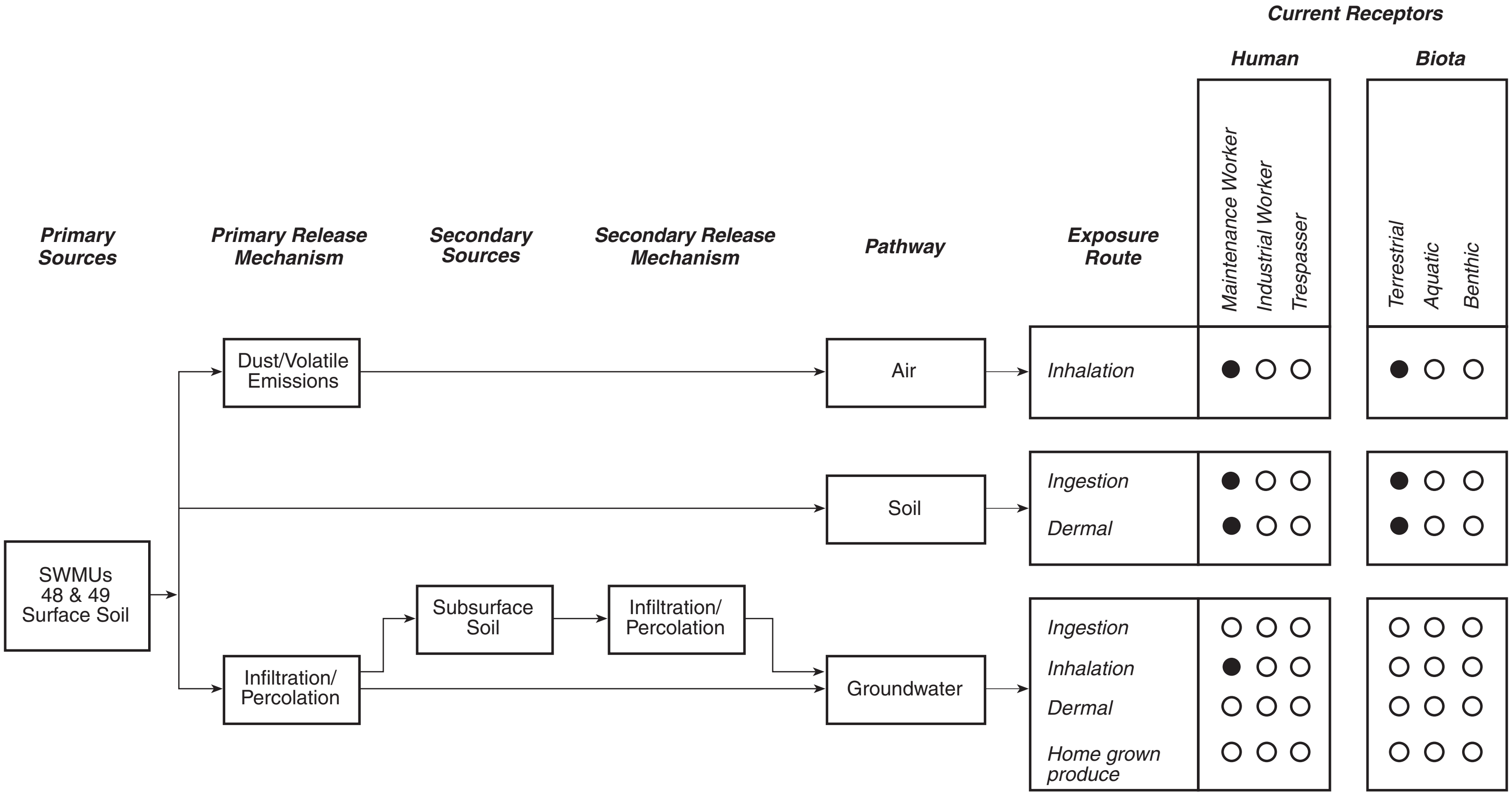
Refined CSMs for SWMUs 48 and 49 are presented on **Figure 6-1** and **Figure 6-2** for current and future exposure scenarios, respectively. SWMUs 48 and 49 are located in the southeastern portion of the HSA, contiguous to SWMUs 50 and 59 and east of the main bridge over the New River (Shaw, 2007). The HSA contains numerous buildings and facilities, and it is likely that the area will remain industrial in nature. The area surrounding RFAAP is not highly developed and land use in the vicinity of the facility is mostly rural, with less rugged areas having been primarily used for agriculture. Residential and recreational areas are located adjacent to the installation (IT, 2001).

The study area for SWMU 48 and SWMU 49 is situated on a bluff approximately 120 ft above and overlooking SWMU 13 and the New River. The overall area is grassy with wooded areas to the south, east, and west. The sites have been revegetated in the years since they were active (Shaw, 2007). Dirt and gravel roads provide access to the sites. There are no structures in the combined study area and no manholes, catch basins, or storm drains located in the immediate vicinity of the area.

SWMU 48 is 1.009 acres in size. This site is known as the Oily Water Burial Area and consists of two unlined trenches, identified as the northern and southern trenches. The area is well-vegetated and is not currently in use. SWMU 49 is known as Red Water Ash Burial No. 2 and is 0.111 acres. The exact location of SWMU 49 has been unclear in previous investigations. Previous investigations combined SWMUs 48, 49, 50, and 59 into one combined study site. However, for this report, we found it more applicable to extract SWMUs 48 and 49 from the combined area due to the fact that their historical uses are so closely linked to each other.

It was conservatively assumed that maintenance workers are the most likely receptors at these sites. Due to installation security, it is unlikely that trespassers could gain access to SWMUs 48 and 49; however, risks associated with the maintenance worker are considered protective of the limited exposure experienced by the trespasser.

If future development occurs, maintenance workers, industrial/commercial workers, and excavation workers could be exposed to surface and subsurface soil as a result of disturbing soil during construction/excavation activities. Therefore, maintenance worker, industrial worker, and excavation worker exposures at SWMUs 48 and 49 were evaluated for total soil in the HHRA. Given the sizes of SWMUs 48 and 49 (1.009 and 0.11 acres, respectively), extensive construction would not be expected. Assuming five-day work weeks, an exposure frequency of 125 days/year was used to represent a six-month construction period, which would seem reasonable for sites of



Pathway	Exposure Route	Maintenance Worker	Industrial Worker	Trespasser	Terrestrial	Aquatic	Benthic
Air	*Inhalation*	●	○	○	●	○	○
Soil	*Ingestion*	●	○	○	●	○	○
	Dermal	●	○	○	●	○	○
Groundwater	*Ingestion*	○	○	○	○	○	○
	Inhalation	●	○	○	○	○	○
	Dermal	○	○	○	○	○	○
	Home grown produce	○	○	○	○	○	○

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

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Figure 6-1. Current Land Use
Conceptual Site Model for SWMUs 48 & 49
Radford Army Ammunition Plant, Virginia

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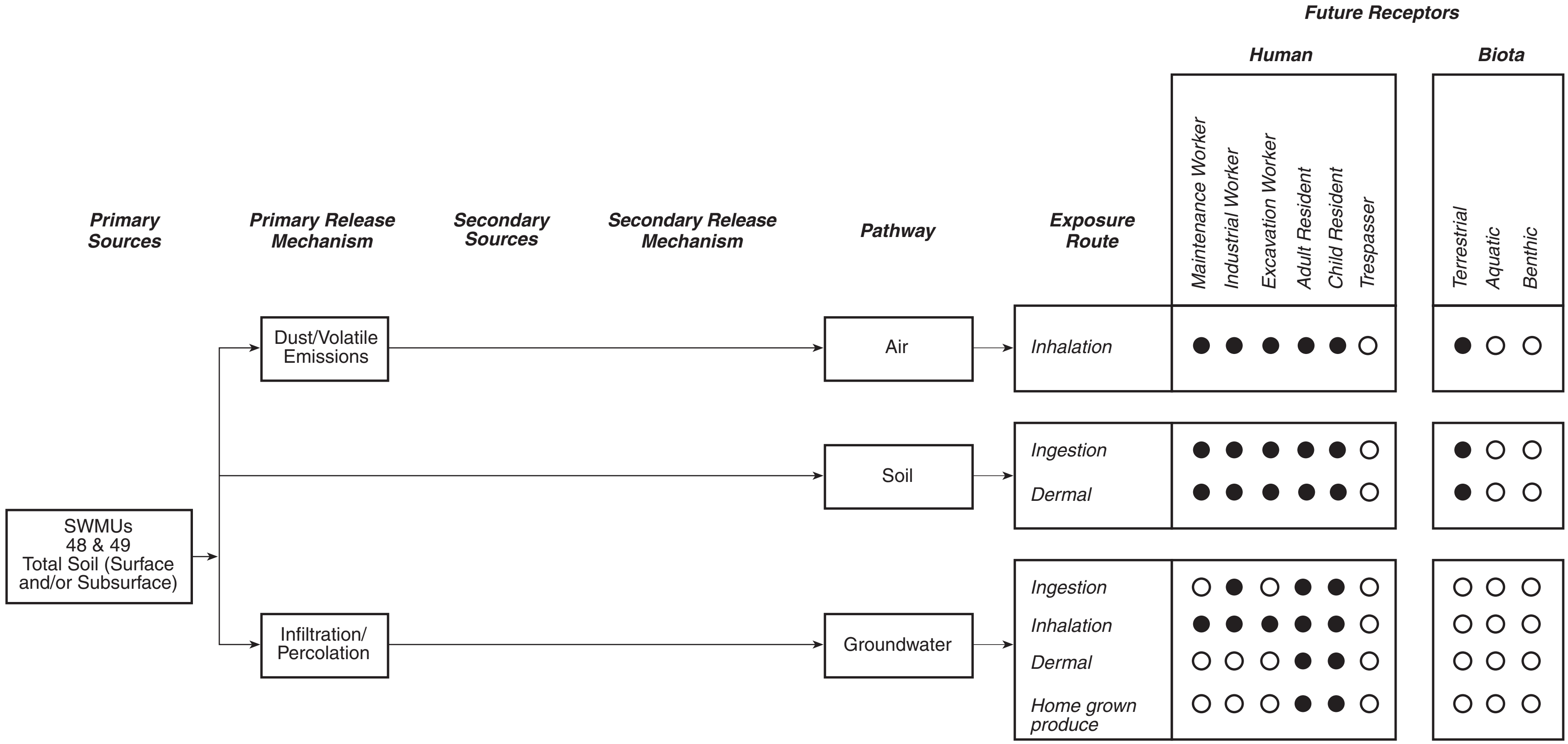

Pathway	Exposure Route	Maintenance Worker	Industrial Worker	Excavation Worker	Adult Resident	Child Resident	Trespasser	Terrestrial	Aquatic	Benthic
Air	*Inhalation*	●	●	●	●	●	○	●	○	○
Soil	*Ingestion*	●	●	●	●	●	○	●	○	○
	Dermal	●	●	●	●	●	○	●	○	○
Groundwater	*Ingestion*	○	●	○	●	●	○	○	○	○
	Inhalation	●	●	●	●	●	○	○	○	○
	Dermal	○	○	○	●	●	○	○	○	○
	Home grown produce	○	○	○	●	●	○	○	○	○

● Indicates pathway/receptor combinations to be evaluated

○ Indicates pathway/receptor combinations incomplete or no source

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Figure 6-2. Future Land Use
Conceptual Site Model for SWMUs 48 & 49
Radford Army Ammunition Plant, Virginia

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these sizes and locations. This exposure frequency is also consistent with values used for previous HHRAs of similar sites at RFAAP.

RFAAP is likely to remain a military installation; therefore, a residential scenario is considered unlikely. However, the residential scenario was evaluated for both areas to assess clean closeout requirements under RCRA.

6.2.2 Identification of Exposure Pathways

The potential receptors identified for the sites include maintenance workers, industrial workers, excavation workers, child residents, adult residents, and lifetime residents. **Appendix E-1, Table E.1-1** and **Appendix E-2, Table E.2-1** summarize the selection of exposure pathways for each receptor listing the rationale for the inclusion or exclusion of each pathway at SWMU 48 and SWMU 49, respectively.

6.2.3 Calculation of EPCs

To calculate intakes, a 95% upper confidence limit (UCL) of the mean concentration for each COPC is used as a conservative estimate of the average concentration in a given environmental medium to which a receptor would be exposed. The 95% UCL estimate is referred to as the EPC. The 95% UCL is used rather than the mean concentration, to account for uncertainty when estimating EPCs from sample data (USEPA, 1989a). Methods used to calculate 95% UCLs are based on guidance provided in the documents *Calculating UCLs for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA, 2002a), *ProUCL Version 4.0 Technical Guide* (USEPA, 2007a), and *ProUCL Version 4.1.00 Technical Guide* (USEPA, 2010a). In general, the method used to calculate a 95% UCL depends on: 1) the prevalence of non-detects; 2) the data distribution (e.g., normal, gamma, or lognormal); and 3) the number of samples in the data set. Non-detects introduce uncertainty in the data set because the true concentration may be between zero to just below the detection limit. Therefore, distributional assumptions are difficult to ascertain for COPCs with a high rate of non-detects.

USEPA’s ProUCL statistical program was used to estimate 95% UCL values for nearly all the soil COPC data sets. Because the removal action at SWMU 48 and the investigation of SWMU 49 occurred at different times, the version of ProUCL that was current at that time was applied. Consequently, ProUCL 4.00.02 (USEPA, 2007a) was used to estimate 95% UCL values for SWMU 49. Values for SWMU 48 were generated using ProUCL 4.1.00 (USEPA, 2010a).

For data sets with non-detects, ProUCL uses the Kaplan-Meier estimation method to derive a recommended 95% UCL (USEPA, 2007a). Where ProUCL recommends the results of more than one statistical approach, the most conservative (highest) 95% UCL value was used in the HHRA. Where fewer than 5 percent of samples had detected values, ProUCL does not recommend a 95% UCL value. In these cases, 95% UCL values were derived using a bootstrap-t statistical program, described by Efron (1982) and discussed in USEPA (1997a). Non-detect values are represented in this bootstrap-t program as random numbers between zero and the detection limit that are generated by the iterative process written into the program. EPCs for soil COPCs are presented in **Appendix E-1, Tables E.1-8 and E.1-9** for SWMU 48 and **Appendix E-2, Tables E.2-8 and E.2-9** for SWMU 49. The output from ProUCL 4.1 is provided in **Appendix E-4** for SWMU 48 and output from ProUCL 4.0 is provided in **Appendix E-5** for SWMU 49. 95% UCL values were not calculated for groundwater; therefore, the MDC for COPCs identified for groundwater were used in the risk assessment. The EPC values for groundwater are shown in **Table E.1-10** for SWMU 48 and **Table E.2-10** for SWMU 49.

Models were used to estimate concentrations of COPCs in air from soil, concentrations of COPCs in air from groundwater, and concentrations of COPCs in homegrown produce from groundwater. These models are discussed in *Section 6.2.4*.

6.2.4 Quantification of Exposure: Calculation of Daily Intakes

For each receptor and pathway, chronic daily intake (CDI, expressed as milligrams of COPC per kilogram body weight per day) for each COPC is estimated by combining the EPC with exposure parameters such as ingestion rate, frequency of contact, duration, and frequency of exposure. In addition, intake parameters are selected so the combination of intake variables results in an estimate of the reasonable maximum exposure for that pathway (USEPA, 1989a). Intake formulas, exposure parameters, and chemical-specific parameters for each of the receptors for SWMU 48 are provided in **Appendix E-1**, **Tables E.1-11 through E.1-20** and **Appendix E-2**, **Tables E.2-11 through E.2-20** for SWMU 49.

The particulate emission factors (PEFs) used to calculate inhalation daily intakes associated with soil were calculated in accordance with the *Supplemental Guidance for Developing SSLs for Superfund Sites* (USEPA, 2002b), as provided in **Appendix E-1, Tables E.1-21 through E.1-35** and **Appendix E-2, Tables E.2-21 through E.2-35**.

For exposures to groundwater via dermal contact, the amount of chemical in water absorbed through the skin must be estimated in order to calculate the dose used in the intake formula. The dose absorbed per unit area per event (DA) is a function of chemical concentration in water, the permeability coefficient for that chemical from water through the skin, and exposure time. Following USEPA (2004a) guidance, receptor-specific DA values were calculated using USEPA's worksheet (2001b) and chemical-specific parameters described in **Appendix E-1**, **Table E.1-26** and **Appendix E-2, Table E.2-26**.

To evaluate inhalation of VOCs from groundwater, EPCs were calculated for VOCs in air using the models depicted in the following sections and provided in **Appendix E-1, Tables E.1-27 through E.1-30** and **Appendix E-2, Tables E.2-27 through E.2-30**. For this scenario, the volatilization model outlined in American Society for Testing and Materials (ASTM) Risk-Based Corrective Action (RBCA) Guidance (ASTM, 1995) for volatilization from groundwater to ambient air was used. In this case, chemical intake is a result of inhalation of outdoor vapors that originate from dissolved hydrocarbons in groundwater located somewhere below ground surface. The equations used to calculate the volatilization factor to ambient air for VOCs in SWMUs 48 and 49 groundwater are presented in **Appendix E-1, Table E.2-27** and **Appendix E-2, Table E.2-27**.

The Johnson and Ettinger Model (USEPA, 2004b) is used to estimate indoor air concentrations of volatiles migrating from groundwater through the groundwater and into a structure. The worksheet for this model was used to estimate air concentrations of VOCs in office buildings and residences for this HHRA (USEPA, 2004c). The worksheets are found in **Appendix E-6** for SWMU 48 and **Appendix E-7** for SWMU 49. The results are given in **Appendix E-1, Table E.1-28** and **Appendix E-2, Table E.2-28**, respectively.

In the event that excavation work is performed onsite, the worker may be exposed to volatile emissions from groundwater below the bottom of the trench. While USEPA does not have a standardized model for estimating concentrations of airborne VOCs in a trench or a pit, the VDEQ provides such a model in their Voluntary Remediation Program (VRP) Risk Assessment Guidance (VDEQ, 2007). The equation and parameters are given in **Appendix E-1, Table E.1-29** and **Appendix E-2, Table E.2-29**.

EPCs of VOCs in air due to volatilization from groundwater were estimated for a showering scenario, applicable to the adult resident, using the Foster-Chrostowski (1987) shower room model. The model is described in **Appendix E-1, Table E.1-30** and **Appendix E-2, Table E.2-30**.

Groundwater-to-air EPCs are summarized in **Appendix E-1, Table E.1-31** for SWMU 48 and **Appendix E-2, Table E.2-31** for SWMU 49.

The transfer of COPCs in groundwater to vegetables by watering a garden was calculated using two equations based on “exposed produce” developed by Baes et al. (1984), as shown in **Appendix E-1, Table E.1-32** and **Appendix E-2, Table E.2-32**. It is noted that USEPA has determined that sufficient data exists for only arsenic, cadmium, mercury, nickel, selenium, and zinc (USEPA, 1996b). Arsenic, cadmium, nickel, and selenium were found to be COPCs in the groundwater associated with SWMUs 48 and 49. The exposure for ingestion of COPCs in home grown produce (vegetables and fruit) by residents was then calculated using the equation and the exposure parameters presented in **Appendix E-1, Table E.1-20** and **Appendix E-2, Table E.2-20**.

6.3 Toxicity Assessment

The methodology used for classifying health effects from exposure to chemicals is recommended by USEPA (2012a). The health effects analysis considers chronic (long-term) exposures. Using the following hierarchy (USEPA, 2003a), the chronic toxicity criteria were obtained from:

- Tier 1 – Integrated Risk Information System (IRIS) (USEPA, 2012a).
- Tier 2 – Provisional Peer Reviewed Toxicity Values (PPRTVs) - as developed on a chemical-specific basis by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (USEPA, 2003a). The PPRTVs were obtained from the USEPA RSL table (USEPA, 2011a) and PPRTV database (USEPA, 2012b).
- Tier 3 – Other Toxicity Values – including additional USEPA and non-USEPA sources of toxicity information, such as the ATSDR Minimum Risk Levels, California EPA, and the Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b).

Toxicity criteria used to quantify non-carcinogenic hazards (risk reference doses - RfDs) and carcinogenic risks (slope factors - CSFs) are presented in **Appendix E-1, Tables E.1-33 through E.1-36** and **Appendix E-2, Tables E.2-33 through E.2-36**.

Quantitative oral toxicity criteria were not available for lead. Lead was selected as a COPC in groundwater at SWMUs 48 and 49 because the MDC of lead (237 µg/L) was greater than the action level of 15 µg/L for lead in drinking water. Although USEPA’s Adult Lead Model (USEPA, 2003b, 2009) is used to evaluate risks associated with nonresidential adult exposures to lead in soil, this model does not account exposures to lead in groundwater. Therefore, groundwater exposures to workers were evaluated with respect to the action level for lead in drinking water.

The potential risks associated with residential exposures to lead are addressed using the Integrated Exposure Uptake Biokinetic (IEUBK) Lead Model for Windows®, Version 1.1, Build 11 (USEPA, 1994a, 2007b, 2010b). The IEUBK model was designed to provide predictions of the probability of elevated blood lead levels for children. This model addresses three components of environmental risk assessments: the multimedia nature of exposures to lead, lead pharmacokinetics, and significant variability in exposure and risk, through estimation of probability distributions of blood lead levels for children exposed to similar environmental concentrations. The arithmetic mean of the lead concentration in groundwater (85 µg/L) was used in conjunction with the default input parameters to represent site-specific exposures to lead at SWMUs 48 and 49. Although lead was not identified as a COPC in soil, the arithmetic means of the lead concentrations in total soil at SWMUs 48 and 49 were used to represent the contribution of lead from soil. The input parameters, probability distribution plots, predicted geometric mean blood lead levels, and the percentages of the population potentially experiencing concentrations above 10 micrograms per deciliter (below which adverse manifestations are not expected) are discussed in *Section 6.4*. The lead risks are considered unacceptable if the child-blood lead level for more than 5 percent of children is estimated to equal or exceed the Centers for Disease Control and Prevention concern threshold of 10 grams per deciliter (g/dL).

The toxic effects associated with chromium are dependent upon its valence state (USEPA, 1998b). Two common forms of chromium are trivalent chromium (chromium III [Cr(III)]) and hexavalent chromium (chromium VI [Cr(VI)]). Cr(III) is the predominant form of chromium in nature and is the less toxic of the two forms. Cr(VI) is the more toxic form of chromium and is considered to be a Class A carcinogen via the route of inhalation. The speciation of Cr(VI) is not routinely performed during a sampling program due to the very short holding time and the unique stability issues associated with Cr(VI) (i.e., it tends to change valence states very easily after sample collection). Unless there is convincing evidence that Cr(VI) may be present at a site (such as its for control of scale in non-contact cooling water piping for a power plant or a chromium plating operation), it is generally not included in an analytical program. For SWMUs 48 and 49, Cr(VI) analyses were not performed for the environmental media samples.

It was assumed that the majority of the chromium that was detected at the site would be in the trivalent form. Cr(VI) is relatively unstable in the environment and is typically converted to Cr(III). As stated in *Water-Related Environmental Fate of 129 Priority Pollutants* (USEPA, 1979), hexavalent chromium or Cr(VI) is a moderately strong oxidizing agent and reacts with reducing materials to form trivalent chromium or Cr(III). Chemical speciation is an important fate process for chromium and in aquatic environments. Cr(VI), if present, would be expected to remain in a soluble form, while Cr(III) would be expected to hydrolyze and precipitate as Cr(OH)3. Cr(III) the most stable form under reducing conditions normally found in natural waters and sediments, and when in solution at pH greater than 5, quickly precipitates due to formation of the insoluble hydroxide or oxide.

Cr(III) is the stable form of chromium in soil (FRTR, 2002). Cr(III) hydroxy compounds precipitate at pH 4.5 and complete precipitation of the hydroxy species occurs at pH 5.5. In contrast to Cr(VI), Cr(III) is relatively immobile in soil. The relationship between chromium concentrations versus pH is shown in the plot provided for SWMU 48 in **Appendix E-8**. Two soil pH measurements (5.23 and 5.52) represent acidic soil conditions, with the total chromium concentrations at 27.2 and 27.5 mg/kg. The relationship between chromium concentrations versus pH is shown in the plot provided for SWMU 49 in **Appendix E-8**. Two soil pH measurements (4.81 and 4.85) represent acidic soil conditions, with total chromium concentrations at 13.6 and 16.7 mg/kg. The pH values at both sites are within the optimal pH range for precipitation of Cr(III). Because of its anionic nature, Cr(VI) associates with soil surfaces at positively charged exchange sites (FRTR, 2002). This association decreases with increasing soil pH. Regardless of pH and redox potential, most Cr(VI) in soil is reduced to Cr(III). Soil organic matter and iron (Fe II) minerals donate electrons in this reaction. The reduction reaction in the presence of organic matter proceeds at a slow rate under normal environmental pH and temperatures, but the rate of reaction increases with decreasing soil pH.

A number of studies have been conducted with respect to the fate and transport of chromium in soil. For example, the objectives of a study conducted by the Oak Ridge National Laboratory (Jardine et al., 1999) were to investigate the impact of coupled hydrologic and geochemical processes on the fate and transport of Cr(VI) in undisturbed soil cores. The reduction of Cr(VI) to Cr(III) was dramatically more significant on soil with higher levels of surface-bound natural organic matter. This indicated that natural organic matter was serving as a suitable reductant during Cr(VI) transport even in the presence of potentially competing geochemical oxidation reactions involving chromium. In another example, seven organic amendments (e.g., composts, manures) were investigated for their effects on the reduction of Cr(VI) in a mineral soil low in organic matter contact (Bolan et al., 2003). Addition of organic amendments enhanced the rate of reduction of Cr(VI) to Cr(III) in the soil. Finally, it was found that the distribution of metal contaminants such as chromium in soil can be strongly localized by transport limitations and redox gradients within soil aggregates (Tokunaga et al., 2001). Shifts in characteristic redox potential and the extent of Cr(VI) reduction to Cr(III) were related to organic matter availability.

The relationship between chromium concentrations in soil and TOC are presented in the plot provided for SWMU 48 in **Appendix E-8**. Although there were only two points for comparison, it is noted that the higher concentration of total chromium (27.5 mg/kg) was associated with the higher value for TOC measurement (16,700 µg/g) in the surface soil samples. The relationship between chromium concentrations in soil and TOC are also presented in the plot provided for SWMU 49 in **Appendix E-8**. The opposite relationship was seen for SWMU 49. This comparison is also based on two samples (one surface soil and one subsurface soil sample).

Increasing chromium concentrations are typically associated with increasing levels of organic matter. Even if trace amounts of Cr(VI) were present at the site, the environmental conditions at RFAAP, including typical precipitation events over the years, would tend to favor the conversion of this form of chromium to the more stable (less toxic) trivalent state. For these reasons, it was assumed that toxicity associated with chromium would be most accurately represented by the use of Cr(III) toxicity data.

6.4 Risk Characterization

Quantitative risks and hazards due to exposure to COPCs are estimated and summarized by combining toxicity criteria (presented in the Toxicity Assessment) with CDIs (calculated in the Exposure Assessment). Methods used to calculate risks and hazards are taken from USEPA (1989a).

For exposures to potential carcinogens, the individual upper-bound excess lifetime cancer risk was calculated by multiplying the estimated CDI by the CSF. In order to assess the individual excess lifetime cancer risks associated with simultaneous exposure to COPCs, the risks derived from the individual chemicals are summed within each exposure pathway. For the residential scenario, carcinogenic risk was evaluated for the lifetime resident.

Non-carcinogenic adverse health effects are calculated by dividing the CDI of each COPC by its RfD, forming an HQ. HQs greater than 1 indicate the potential for adverse health effects. To estimate non-carcinogenic adverse health effects due to simultaneous exposure to several COPCs, HQs for individual COPCs are summed within each exposure pathway to form an HI. As with HQs, HIs that are greater than 1 indicate potential adverse health effects. In such cases, COPCs are divided into categories based on the target organ affected (e.g., liver, kidney) and target organ-specific HIs are recalculated. Non-carcinogenic hazards were evaluated for both child and adult residents independently.

Excess lifetime cancer risks derived in this report are compared with USEPA's target risk range for Superfund sites of 1E-06 to 1E-04 (USEPA, 1989a). In addition, USEPA's OSWER has issued a directive (USEPA, 1991a) clarifying the role of HHRA in the Superfund process. The directive states that, if the cumulative carcinogenic risk to a receptor (based on reasonable maximum exposure for both current and future land use) is less than 1E-04 and the non-carcinogenic HI is equal to or less than 1, action generally is not warranted unless adverse environmental effects are likely.

Calculation of risks and hazards due to exposure to COPCs are provided in **Appendix E-1, Tables E.1-37 through E.1-58** for SWMU 48 and **Appendix E-2, Tables E.2-37 through E.2-58** for SWMU 49. The risks and HIs for each receptor are presented in **Appendix E-l, Tables E.1-59 through E.1-69** (SWMU 48) and **Appendix E-2, Tables E.2-59 through E.2-69** (SWMU 49). These risks and hazards are summarized in **Table 6-4** (SWMU 48) and **Table 6-5** (SWMU 49). A refinement of the HIs based on target organs is conducted by calculating HIs on a target organ-specific basis. In addition, **Appendix E-1, Tables E.1-70 through E.1-80** (SWMU 48) and **Appendix E-2, Tables E.2-70 through E.2-80** (SWMU 49) summarize risks and hazards for risk/HI drivers (i.e., those COPCs contributing to a total risk greater than 1.E-04 or a total target organ hazard greater than 1).

6.4.1 Lead Exposure Models

The MDC for lead in groundwater for SWMUs 48 and 49 (237 µg/L) was above the lead SL of 15 µg/L, and therefore, the potential hazard associated with lead was evaluated using IEUBK model for the residential scenario (USEPA, 2007b, 2010b).

The modeling was based on the site-specific mean concentration of lead detected in groundwater (85 µg/L). Lead is not a COPC at either SWMU 48 or SWMU 49. The arithmetic mean concentrations of lead in soil were used, however, to represent the contribution of lead in soil to the total intake of lead. The IEUBK model predicts the probability of children expected to have blood levels of 10 g/dL or greater. Percentages below 5 percent are considered to be protective of human health. For SWMU 48, the assumptions, corresponding input parameters, distribution probability plot, and results of the model are presented in **Appendix E-1, Table E.1-81**. Default parameters were used for the IEUBK model. The arithmetic means for lead in groundwater (85 µg/L) and total soil (24.4 mg/kg) were used in the model. For the child resident, the IEUBK resulted in 21.2 percent probability that child blood levels would exceed 10 g/dL (<5 percent therefore fails).

Table 6-4
Summary of Risks and Hazards
SWMU 48

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Current maintenance worker	5E-07	5E-02	N/A	N/A
Future maintenance worker	6E-07	8E-02	N/A	N/A
Future industrial worker [b]	**1E-04**	**2E+01**	**Total Soil** Arsenic **Groundwater** Carbon Tetrachloride 1,2-Dichloroethane TCDD TE Trichloroethene Arsenic	**Liver** (7.6) - Groundwater [Carbon tetrachloride - Ing (0.4); Iron - Ing (1.7); Nickel - Ing (0.1); Thallium - Ing (5.3)] **CNS** (2.7) - Groundwater [TCDD TE - Ing (0.2); Aluminum - Ing (0.5); Manganese - Ing (1.8)] **Blood** (7.1) - Groundwater [Iron - Ing (1.7); Thallium- Ing (5.3)] **GI Tract** (1.8) - Groundwater [Iron - Ing (1.7)] **Thyroid** (4.0) - Groundwater [Cobalt - Ing (4.0)] **Hair** (5.3) - Groundwater [Thallium - Ing (5.3)] **Site concentrations of lead in groundwater were above the action level for lead in drinking water.**
Future excavation worker	3E-07	**1.0E+00**	N/A	N/A
Future adult resident[b]	N/A	**9E+01**	N/A	**Liver** (27.4) - Groundwater [Carbon Tetrachloride - Ing (1.2), Derm (0.3), Inh (2.5); Iron - Ing (5.4); Nickel - Ing (0.5);Thallium - Ing (16); 1,2-Dichloroethane - Inh (0.8)] **CNS** (19.1) - Groundwater [TCDD TE - Ing (0.6), Derm (11); Aluminum - Ing (1.7); Manganese - Ing (5.7)] **Blood** (22.0) - Groundwater [Iron - Ing (5.4); Thallium - Ing (16)] **Skin** (1.6) - Groundwater [Arsenic - Ing (1.5)] **Vascular Effects** (1.5) - Groundwater [Arsenic - Ing (1.5)] **GI Tract** (5.6) - Groundwater [Iron - Ing (5.4)] **Hair** (16.5) - Groundwater [Thallium - Ing (16)] **Kidney** (2.5) - Groundwater [Barium - Ing (0.8); Cadmium - Ing (0.3); Nickel - Ing (0.5); Vanadium - Ing (0.9)] **Thyroid** (12.4) - Groundwater [Cobalt - Ing (12)] **Heart** (26.8) - Groundwater [Trichloroethene - Ing (1.8), Derm (0.3), Inh (25)] **Developmental Immunotoxicity** (2.1) - Groundwater [Trichloroethene - Ing (1.8),Derm (0.3)] **Thymus** (26.8) - Groundwater [Trichloroethene - Ing (1.8), Derm (0.3), Inh (25)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above health protective criterion.**

Table 6-4
Summary of Risks and Hazards
SWMU 48

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future child resident[b]	**6E-04**	**1.5E+02**	**Total Soil** Arsenic **Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	**Spleen** (1.0) - Groundwater - [Nickel - Ing (1.0)] **Heart** (5.0) - Groundwater [Trichloroethene - Ing (4.2) and Derm (0.7)] **Developmental Immunotoxicity** (4.9) - Groundwater [Trichloroethene - Ing (4.2) and Derm (0.7)] **Thymus** (5.0) - Groundwater [Trichloroethene - Ing (4.2) and Derm (0.7)] **Liver** (57) - Soil [Iron - Ing (0.9); Thallium - Ing (0.2); Groundwater [Carbon tetrachloride - Ing (2.9), Derm (0.8); Pentachlorophenol - Derm (0.1); Iron - Ing (13); Nickel - Ing (1.0); Thallium - Ing (38)] **CNS** (46) - Soil [Aluminum - Ing (0.4); Manganese - Ing (0.5), Derm (0.3)] Groundwater [TCDD TE - Ing (1.4) and Derm (26); Aluminum - Ing (3.9); Manganese - Ing (13); Selenium - Ing (0.1)] **Blood** (52) - Soil [Iron - Ing (0.9); Thallium - Ing (0.2)] Groundwater [Iron - Ing (13); Selenium - Ing (0.1); Thallium - Ing (38)] **Skin** (3.9) - Soil [Arsenic - Ing (0.2)] Groundwater [Arsenic - Ing (3.5); Selenium - Ing (0.1); Silver - Ing (0.1)] **Vascular Effects** (3.7) - Soil [Arsenic - Ing (0.2)] Groundwater [Arsenic - Ing (3.5)] **GI Tract** (14) - Soil [Iron - Ing (0.9)] Groundwater [Copper - Ing (0.2); Beryllium - Ing (0.1), Derm - Ing (0.1); Iron - Ing (13)] **Hair** (39) - Soil [Thallium - Ing (0.2)] Groundwater [Thallium - Ing (38)] **Kidney** (6.2) - Soil [Vanadium - Ing (0.2), Derm (0.2)] Groundwater [Barium - Ing (1.8); Cadmium - Ing (0.6); Nickel - Ing (1.0); Vanadium - Ing (1.8), Derm (0.5)] **Thyroid** (30) - Soil [Cobalt - Ing (0.8)] Groundwater [Cobalt - Ing (29)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above health protective criterion.**
Future lifetime resident	**2E-03**	N/A	**Total Soil** Arsenic **Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,1-Dichloroethane 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	N/A

Table 6-4
Summary of Risks and Hazards
SWMU 48

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future off-site maintenance worker	1E-8	2E-04	N/A	N/A
Future off-site industrial worker [b]	**1E-04**	**2E+01**	**Groundwater** Carbon Tetrachloride 1,2-Dichloroethane TCDD TE Trichloroethene Arsenic	**Liver** (7.6) - Groundwater [Carbon tetrachloride - Ing (0.4); Iron - Ing (1.7); Nickel - Ing (0.1); Thallium - Ing (5.3)] **CNS** (2.6) - Groundwater [TCDD TE - Ing (0.2); Aluminum - Ing (0.5); Manganese - Ing (1.8)] **Blood** (7.0) - Groundwater [Iron -Ing (1.7), Thallium- Ing (5.3)] **GI Tract** (1.7) - Groundwater [Iron - Ing (1.7)] **Thyroid** (4.0) - Groundwater [Cobalt - Ing (4.0)] **Hair** (5.3) - Groundwater [Thallium - Ing (5.3)] **Site concentrations of lead in groundwater were above the action level for lead in drinking water.**
Future off-site excavation worker	1E-07	5E-02	N/A	N/A
Future off-site adult resident[b]	N/A	**9E+01**	N/A	**Liver** (27) - Groundwater [Carbon Tetrachloride - Ing (1.2), Derm (0.3), Inh(2.5); Iron - Ing (5.4); Thallium - Ing (16); 1,2-Dichloroethane - Inh (0.8)] **CNS** (19) - Groundwater [TCDD TE - Ing (0.6), Derm (11); Aluminum - Ing (1.7); Manganese - Ing (5.7)] **Blood** (22) - Groundwater [Iron - Ing (5.4); Thallium - Ing (16)] **Skin** (1.6) - Groundwater [Arsenic - Ing (1.5)] **Vascular Effects** (1.5) - Groundwater [Arsenic - Ing (1.5)] **GI Tract** (5.5) - Groundwater [Iron - Ing (5.4)] **Hair** (16) - Groundwater [Thallium - Ing (16.0)] **Kidney** (2.4) - Groundwater [Barium - Ing (0.8); Cadmium - Ing (0.3); Nickel - Ing (0.5); Vanadium - Ing (0.8), Derm (0.1)] **Thyroid** (12) - Groundwater [Cobalt - Ing (12.0)] **Heart** (27) - Groundwater [Trichloroethene - Ing (1.8), Derm (0.3) and Inh (25)] **Developmental Immunotoxicity** (2.1) - Groundwater [Trichloroethene - Ing (1.8) and Derm (0.3)] **Thymus** (27) - Groundwater [Trichloroethene - Ing (1.8), Derm (0.3) and Inh (25)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above health protective criterion.**

Table 6-4
Summary of Risks and Hazards
SWMU 48

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future off-site child resident[b]	**6E-04**	**1.4E+02**	**Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	**Spleen** (1.0) - Groundwater - [Nickel - Ing (1.0)] **Heart** (5.0) - Groundwater [Trichloroethene - Ing (4.2) and Derm (0.7)] **Developmental Immunotoxicity** (4.9) - Groundwater [Trichloroethene - Ing (4.2) and Derm (0.7)] **Thymus** (5.0) - Groundwater [Trichloroethene - Ing (4.2) and Derm (0.7)] **Liver** (56) - Groundwater [Carbon tetrachloride - Ing (2.9), Derm (0.8); Pentachlorophenol - Derm (0.1); Iron - Ing (13); Nickel - Ing (1.0); Thallium - Ing (38.0)] **CNS** (45) - Groundwater [TCDD TE - Ing (1.4), Derm (26); Aluminum - Ing (3.9); Manganese - Ing (13); Selenium - Ing (0.1)] **Blood** (51) - Groundwater [Iron - Ing (13); Selenium - Ing (0.1); Thallium - Ing (38)] **Skin** (3.7) - Groundwater [Arsenic - Ing (3.5; Selenium - Ing (0.1); Silver - Ing (01.)] **Vascular Effects** (3.5) - Groundwater [Arsenic - Ing (3.5)] **GI Tract** (13) - Groundwater [Copper - Ing (0.2); Iron - Ing (13); Beryllium - Ing (0.1), Derm (0.1)] **Hair** (38) - Groundwater [Thallium - Ing (38)] **Kidney** (5.9) - Groundwater [Barium - Ing (1.8); Cadmium - Ing (0.6); Nickel - Ing (1.0); Vanadium - Ing (1.8), Derm (0.5)] **Thyroid** (29) - Groundwater [Cobalt - Ing (29)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above health protective criterion.**
Future off-site lifetime resident	**2E-03**	N/A	**Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,1-Dichloroethane 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	N/A

NA = Not Applicable
HI = Hazard Index
HQ = Hazard Quotient
IEUBK Model = Integrated Exposure Uptake Biokinetic Model
Bold = Exceeds USEPA Risk or Hazard Range
Ing = Ingestion; Inh - Inhalation; Derm = Dermal
GI = Gastrointestinal
CNS = Central Nervous System
TCDD TE = DioxinToxicity Equivalent
NOTE: Arsenic, cobalt, manganese, thallium, and vanadium are within background concentrations for total soil.

a) Cumulative HIs and individual HQs are rounded to the nearest tenth. HIs > 1 and HQs > 0.1 are listed.
b) For this receptor, site concentrations of lead in groundwater were above the health protective criterion for lead.

Table 6-5
Summary of Risks and Hazards
SWMU 49

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Current maintenance worker	9E-07	5E-02	N/A	N/A
Future maintenance worker	**3E-06**	6E-02	**Total Soil** Aroclor 1232	N/A
Future industrial worker[b]	**2E-04**	**2E+01**	**Total Soil** TCDD TE Aroclor 1232 Arsenic **Groundwater** Carbon Tetrachloride 1,2-Dichloroethane TCDD TE Trichloroethene Arsenic	**Liver** (7.7) - Groundwater [Carbon Tetrachloride - Ing (0.4); Iron - Ing (1.7); Nickel - Ing (0.1); Thallium - Ing (5.3)] **CNS** (2.7) - Groundwater [Aluminum - Ing (0.5); Manganese - Ing (1.8); TCDD TE - Ing (0.2)] **Blood** (7.1) - Groundwater [Iron - Ing (1.7); Thallium- Ing (5.3)] **GI Tract** (1.8) - Groundwater [Iron - Ing (1.7)] **Thyroid** (4.0) - Groundwater - [Cobalt - Ing (4.0)] **Hair** (5.3) - Groundwater [Thallium - Ing (5.3)] **Site concentrations of lead in groundwater were above the action level for lead in drinking water.**
Future excavation worker	9E-07	6E-01	N/A	N/A
Future adult resident[b]	N/A	**9E+01**	N/A	**Liver** (27.4) - Groundwater [Carbon Tetrachloride - Ing (1.2), Derm (0.3), Inh (2.5); Iron - Ing (5.4); Nickel - Ing (0.5); Thallium - Ing (16); 1,2-Dichloroethane - Inh (0.8)] **CNS** (19.1) - Groundwater [Aluminum - Ing (1.7); Manganese - Ing (5.7), TCDD TE - Ing (0.6), Derm (11.0)] **Blood** (22.0) - Groundwater [Iron - Ing (5.4); Thallium - Ing (16)] **Skin** (1.6) - Groundwater [Arsenic - Ing (1.5)] **Vascular Effects** (1.5) - Groundwater [Arsenic - Ing (1.5)] **GI Tract** (5.6) - Groundwater [Iron - Ing (5.4)] **Hair** (16.5) - Groundwater [Thallium - Ing (16)] **Kidney** (2.4) - Groundwater [Barium - Ing (0.8); Cadmium - Ing (0.3); Nickel - Ing (0.5); Vanadium - Ing (0.8), Derm (0.1)] **Thyroid** (12.4) - Groundwater [Cobalt - Ing (12)] **Heart** (26.8) - Groundwater [Trichloroethene - Ing (1.8), Derm (0.3), Inh (25)] **Thymus** (26.8) - Groundwater [Trichloroethene - Ing (1.8), Derm (0.3), Inh (25)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above the health protective criterion for lead.**

Table 6-5
Summary of Risks and Hazards
SWMU 49

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future child resident[b]	**6E-04**	**1E+02**	**Total Soil** TCDD TE Aroclor 1232 Arsenic **Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	**Spleen** (1.0) - Groundwater - [Nickel - Ing (1.0)] **Liver** (57.2) - Soil [Iron - Ing (0.5); Thallium - Ing (0.9)] Groundwater [Carbon Tetrachloride - Ing (2.9), Derm (0.8); Pentachlorophenol - Derm (0.1); Iron - Ing (13); Nickel - Ing (1.0); Thallium - Ing (38)] **CNS** (45.8) - Soil [Aluminum - Ing (0.3); Manganese - Ing (0.2), Derm (0.1); TCDD TE - Ing (0.3)], Groundwater [Aluminum - Ing (3.9); Manganese - Ing (13); Selenium - Ing (0.1); TCDD TE - Ing (1.4), Derm (26)] **Blood** (52.5) - Soil [Iron - Ing (0.5); Thallium - Ing (0.9)] Groundwater [Iron - Ing (13); Selenium - Ing (0.1); Thallium - Ing (38)] **Skin** (3.9) - Soil [Arsenic - Ing (0.2)] Groundwater [Arsenic - Ing (3.5); Selenium - Ing (0.1); Silver - Ing (0.1)] **Vascular Effects** (3.7) - Soil [Arsenic - Ing (0.2)] Groundwater [Arsenic - Ing (3.5)] **GI Tract** (13.5) - Soil [Iron - Ing (0.5)] Groundwater [Copper - Ing (0.2); Iron - Ing (13)] **Hair** (39.3) - Soil [Thallium - Ing (0.9)] Groundwater [Thallium - Ing (38)] **Kidney** (53.2) - Soil [Vanadium - Ing (0.2), Derm (0.2)] Groundwater [Barium - Ing (1.8); Cadmium - Ing (0.6); Nickel - Ing (1.0); Vanadium - Ing (1.8), Derm (0.5)] **Thyroid** (29.0) - Soil [Cobalt - Ing (0.2)] Groundwater [Cobalt - Ing (29)] **Heart** (5.0) - Groundwater [Trichloroethene - Ing (4.2), Derm (0.7)] **Thymus** (5.0) - Groundwater [Trichloroethene - Ing (4.2), Derm (0.7)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above the health protective criterion for lead.**
Future lifetime resident	**2E-03**	N/A	**Total Soil** TCDD TE Aroclor 1232 Arsenic **Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,1-Dichloroethane 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	N/A

Table 6-5
Summary of Risks and Hazards
SWMU 49

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future off-site maintenance worker	3E-09	5E-05	N/A	N/A
Future off-site industrial worker[b]	**1E-04**	**2E+01**	**<u>Groundwater</u>** Carbon Tetrachloride 1,2-Dichloroethane TCDD TE Trichloroethene Arsenic	**Liver** (7.6) - Groundwater [Carbon Tetrachloride - Ing (0.4); Iron - Ing (1.7); Nickel - Ing (0.1); Thallium - Ing (5.3)] **CNS** (2.6) - Groundwater [Aluminum - Ing (0.5); Manganese - Ing (1.8); TCDD TE - Ing (0.2)] **Blood** (7.0) - Groundwater [Iron - Ing (1.7); Thallium - Ing (5.3)] **GI Tract** (1.8) - Groundwater [Iron - Ing (1.7)] **Thyroid** (4.0) - Groundwater [Cobalt - Ing (4.0)] **Hair** (5.3) - Groundwater [Thallium - Ing (5.3)] **Site concentrations of lead in groundwater were above the action level for lead in drinking water.**
Future off-site excavation worker	4E-08	2E-02	N/A	N/A
Future off-site adult resident[b]	N/A	**9E+01**	N/A	**Liver** (27.2) - Groundwater [Carbon Tetrachloride - Ing (1.2), Derm (0.3), Inh (2.5); Iron - Ing (5.4); Nickel - Ing (0.5); Thallium - Ing (16); 1,2-Dichloroethane - Inh (0.8)] **CNS** (18.9) - Groundwater [Aluminum - Ing (1.7); Manganese - Ing (5.7); TCDD TE - Ing (0.6), Derm (11.0)] **Blood** (21.9) - Groundwater [Iron - Ing (5.4); Thallium - Ing (16)] **Skin** (1.6) - Groundwater [Arsenic - Ing (1.5)] **Vascular Effects** (1.5) - Groundwater [Arsenic - Ing (1.5)] **GI Tract** (5.5) - Groundwater [Iron - Ing (5.4)] **Hair** (16.4) - Groundwater [Thallium - Ing (16)] **Kidney** (2.4) - Groundwater [Barium - Ing (0.8); Cadmium - Ing (0.3); Nickel - Ing (0.5); Vanadium - Ing (0.8), Derm (0.1)] **Thyroid** (12.3) - Groundwater [Cobalt - Ing (12)] **Heart** (26.8) - Groundwater [Trichloroethene - Ing (1.8); Derm (0.3); Inh (25)] **Thymus** (26.8) - Groundwater [Trichloroethene - Ing (1.8); Derm (0.3); Inh (25)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above the health protective criterion.**

Table 6-5
Summary of Risks and Hazards
SWMU 49

Timeframe/Receptor	Risk	HI	Risk Drivers	Target Organ Segregation HI>1[a]
Future off-site child resident[b]	**6E-04**	**1E+02**	**Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	**Spleen** (1.0) - Groundwater [Nickel - Ing (1.0)] **Liver** (55.7) - Groundwater [Carbon tetrachloride - Ing (2.9), Derm (0.8); Pentachlorophenol - Derm (0.1); Iron - Ing (13); Nickel - Ing (1.0); Thallium - Ing (38)] **CNS** (44.9) - Groundwater [Aluminum - Ing (3.9); Manganese - Ing (13); TCDD TE - Ing (1.4), Derm (26)] **Blood** (51.0) - Groundwater [Iron - Ing (13); Selenium - Ing (0.1); Thallium - Ing (38)] **Skin** (3.7) - Groundwater [Arsenic - Ing (3.5); Selenium - Ing (0.1); Silver - Ing (0.1)] **Vascular Effects** (3.5) - Groundwater [Arsenic - Ing (3.5)] **GI Tract** (12.8) - Groundwater [Copper - Ing (0.2), Iron - Ing (13)] **Hair** (38.4) - Groundwater [Thallium - Ing (38)] **Kidney** (5.9) - Groundwater [Barium - Ing (1.8); Cadmium - Ing (0.6); Nickel - Ing (1.0); Vanadium - Ing (1.8), Derm (0.5)] **Thyroid** (28.8) - Groundwater (Cobalt - Ing (29)] **Heart** (5.0) - Groundwater [Trichloroethene - Ing (4.2), Derm (0.7)] **Thymus** (5.0) - Groundwater (Trichloroethene - Ing (4.2), Derm (0.7)] **Based on the results of the IEUBK Model, site concentrations of lead in groundwater were above health protective criterion.**
Future off-site lifetime resident	**2E-03**	N/A	**Groundwater** bis(2-Ethylhexyl)phthalate Carbon Tetrachloride 1,1-Dichloroethane 1,2-Dichloroethane Pentachlorophenol TCDD TE Trichloroethene Arsenic	N/A

NA = Not Applicable
HI = Hazard Index
HQ = Hazard Quotient
Bold = Exceeds USEPA Risk or Hazard Range
Ing = Ingestion; Inh - Inhalation; Derm = Dermal
GI = Gastrointestinal
CNS = Central Nervous System
TCDD TE = Dioxin Toxicity Equivalent
NOTE: Arsenic, iron, manganese, thallium, and vanadium are within background concentrations for total soil.

a) Cumulative HIs and individual HQs are rounded to the nearest tenth. HIs > 1 and HQs > 0.1 are listed.
b) For this receptor, site concentrations of lead in groundwater were above the health protective criterion for lead.

For SWMU 49, the assumptions, corresponding input parameters, distribution probability plot, and results of the model are presented in **Appendix E-2, Table E.2-81**. Default parameters were used for the IEUBK model. The arithmetic means for lead in groundwater (85 µg/L) and total soil (26.0 mg/kg) were used in the model. For the child resident, the IEUBK resulted in 21.4 percent probability that child blood levels would exceed 10 g/dL (<5 percent therefore fails).

Based on comparison with the MCL for lead, groundwater at SWMUs 48 and 49 fails the lead exposure assessment for the maintenance worker, the industrial worker, and adult resident. Results of the IEUBK model indicate that groundwater at SWMUs 48 and 49 fails the lead exposure assessment for the child resident.

6.4.2 Iron Margin of Exposure Evaluation

Because iron concentrations in soil resulted in an HQ of 0.5 or higher for the child resident at SWMUs 48 and 49, a “margin of exposure evaluation” was conducted. This evaluation consists of a comparison of estimated intake of iron to the RDA and concentrations known to cause adverse health effects in children. The calculated intake of iron via the route of ingestion is compared with amounts that are associated with an RDA of 10 milligrams per day (mg/day) (0.36 to 1.11 mg/kg-day) for children from 6 months to 10 years of age (USEPA, 1996a).

For SWMU 48, the calculated intake of iron via ingestion of groundwater was 8.8 mg/kg-day and ingestion of total soil was 0.65 mg/kg-day for the child resident. The total estimated intake of iron by ingestion was 9.5 mg/kg-day. The intake calculated for groundwater and total soil at SWMU 48 was above the allowable range (0.36 to 1.11 mg/kg-day), primarily due to the contribution of groundwater.

For SWMU 49, the calculated intake of iron via ingestion of groundwater was 8.8 mg/kg-day and ingestion of total soil was 0.37 mg/kg-day for the child resident. The total estimated intake of iron by ingestion was 9.2 mg/kg-day. The intake calculated for groundwater and total soil at SWMU 49 was above the allowable range (0.36 to 1.11 mg/kg-day), primarily due to the contribution of groundwater.

6.4.3 Background

Statistical evaluations were conducted to compare inorganic COPC drivers in soil at SWMUs 48 and 49 with background concentrations presented in the *RFAAP Facility-Wide Background Study Report* (IT, 2001). There is no background data set for groundwater.

These evaluations followed the procedures outlined in the USEPA *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (USEPA, 2002c) and were conducted using USEPA’s ProUCL statistical program. Similar to the approach used to estimate EPCs, ProUCL 4.1.00 was applied to SWMU 48 and ProUCL 4.00.02 was applied to SWMU 49. Statistical analyses included distribution testing of site data sets and background data sets, evaluation of data using descriptive summary statistics, and comparisons of site data to background. Distribution testing showed that either the site data sets or the background data sets in each case were not normal and, therefore, consistent with *Section 4.1* of the above-referenced USEPA guidance, comparisons of site to background were conducted using non-parametric testing rather than attempting to transform the data sets logarithmically. Using ProUCL 4.00.02, Wilcoxon Mann Whitney tests for SWMU 49 were conducted for each metal with background data sets to evaluate whether site concentrations were consistently higher or lower than the background data set. Due to updated methods in ProUCL 4.1.00, Gehans test was conducted for each metal with background data sets, unless otherwise noted, to evaluate whether site concentrations at SWMU 48 were consistently higher or lower than the background data set. Gehans test was used because it was found to handle data sets with multiple detection limits better than the Wilcoxon Mann Whitney test.

For SWMU 48, notes on the methodology and the results of the background evaluation are summarized in **Table 6-6**. The ProUCL 4.1 output is provided in **Appendix E-9**. Based on the background evaluation, the COPCs identified for SWMU 48 that are detected above background concentrations include barium for surface soil and aluminum and iron for total soil.

For SWMU 49, notes on the methodology and the results of the background evaluation are summarized in **Table 6-7**. The ProUCL 4.00.02 output is provided in **Appendix E-10**. The COPCs identified for SWMU 49 that were detected above background concentrations include aluminum, arsenic, mercury, and selenium for surface soil and aluminum and cobalt for total soil.

6.5 Uncertainties

Risk assessments involve the use of assumptions, judgments, and incomplete data to varying degrees that contribute to the uncertainty of the final estimates of risk. Uncertainties result both from the use of assumptions or models in lieu of actual data and from the error inherent in the estimation of risk-related parameters and may cause risk to be overestimated or underestimated. Based on the uncertainties described below, this risk assessment should not be construed as presenting an absolute estimate of risk to persons potentially exposed to COPCs.

Consideration of the uncertainty attached to various aspects of the risk assessment allows better interpretation of the risk assessment results and understanding of the potential adverse effects on human health. In general, the primary sources of uncertainty are associated with environmental sampling and analysis, selection of chemicals for evaluation, toxicological data, and exposure assessment. The effects of these uncertainties on the risk estimates are discussed below.

6.5.1 Environmental Sampling and Analysis

If the samples do not adequately represent media at SWMUs 48 and 49, hazard/risk estimates could be overestimated or underestimated. The sampling and analysis plan was designed to investigate anticipated areas of contamination and delineate area(s) of concern. Therefore, there is less chance that the hazard/risk estimates are biased low. Also, if the analytical methods used do not apply to some chemicals that are present at each area, risk could be underestimated. Because the analytical methods at the site were selected to address all chemicals that are known or suspected to be present on the basis of the history of each area, the potential for not identifying a COPC is reduced.

Uncertainty in environmental chemical analysis can stem from several sources including errors inherent in the sampling or analytical procedures. Analytical accuracy errors or sampling errors can result in rejection of data, which decreases the available data for use in the HHRA, or in the qualification of data, which increases the uncertainty in the detected chemical concentrations. There is uncertainty associated with chemicals reported in samples at concentrations below the method reporting limit but still included in data analysis and with those chemicals qualified “J” indicating that the concentrations are estimated. Another issue involves the amount of blank

Table 6-6
Summary of Site vs. Background Statistical Analyses - SWMU 48

Inorganic Constituent	Data Distribution [a]		Site > Background? [b]	Basis [b]
	SWMU-48	Background		
Surface Soil (0 - 0.5 feet)				
Aluminum	Detects ≤ 4 [c]	Not Normal	No	Wilcoxon Mann Whitney Test
Antimony	Not COPC [d]	All nondetect	-- [d]	--
Arsenic	Detects ≤ 4	Not Normal	No	Gehan's Test
Barium	Detects ≤ 4	Normal	**Yes**	Gehan's Test
Beryllium	Not COPC	Not Normal	--	--
Cadmium	Not COPC	Detects < 3	--	--
Calcium	Not COPC	Not Normal	--	--
Chromium	Detects ≤ 4	Not Normal	No	Wilcoxon Mann Whitney Test
Cobalt	Detects ≤ 4	Not Normal	No	Gehan's Test
Copper	Not COPC	Not Normal	--	--
Iron	Detects ≤ 4	Not Normal	No	Wilcoxon Mann Whitney Test
Lead	Not COPC	Not Normal	--	--
Magnesium	Not COPC	Not Normal	--	--
Manganese	Detects ≤ 4	Not Normal	No	Wilcoxon Mann Whitney Test
Mercury	Detects ≤ 4	Not Normal	No	Gehan's Test
Nickel	Not COPC	Not Normal	--	--
Potassium	Not COPC	Not Normal	--	--
Selenium	Not COPC	Not Normal	--	--
Thallium	Detects ≤ 4	Not Normal	No	Wilcoxon Mann Whitney Test
Vanadium	Not COPC	Not Normal	--	--
Zinc	Detects ≤ 4	Not Normal	No	Wilcoxon Mann Whitney Test
Total Soil [e]				
Aluminum	Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Antimony	Not COPC	All nondetect	--	--
Arsenic	Normal	Not Normal	No	Gehan's Test
Barium	Not COPC	Not Normal	--	--
Beryllium	Not COPC	Not Normal	--	--
Cadmium	Not COPC	Not Normal	--	--
Calcium	Not COPC	Not Normal	--	--
Chromium	Normal	Normal	No	T-test
Cobalt	Not Normal	Not Normal	No	Gehan's Test
Copper	Not COPC	Not Normal	--	--
Iron	Normal	Normal	**Yes**	T-test
Lead	Not COPC	Not Normal	--	--
Magnesium	Not COPC	Not Normal	--	--
Manganese	Not Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Mercury	Not Normal	Not Normal	No	Gehan's Test
Nickel	Not COPC	Not Normal	--	--
Potassium	Not COPC	Not Normal	--	--
Selenium	Not COPC	Detects < 3	--	--
Thallium	Normal	Not Normal	No	Gehan's Test
Vanadium	Normal	Normal	No	T-test
Zinc	Not COPC	Not Normal	--	--

[a] Background distribution as determined by ProUCL version 4.1 Goodness-of-Fit test, NDs included (as DL/2), Shapiro-Wilks test, if available otherwise Lillefors test results used. Details in **Appendix E-9**. Site distribution as determined by ProUCL version 4.1 95% UCL calculation.

[b] Two sample (population) hypothesis testing, two-sided test, using ProUCL version 4.1.
"Without ND" option used if 100% detects, otherwise "With ND" option employed.
T-test used if both site and background data sets had normal distributions, otherwise Gehan's test used, unless noted below.
Wilcoxon Mann Whitney Test used if both data sets were 100 percent detect and data distribution not normal.
95% confidence level selected. Details in **Appendix E-9**.

[c] If detects ≤ 4, data distribution could not be determined.

[d] No statistical results presented, as chemical not COPC/COPEC.

[e] Total soil = samples collected from surface to bottom of the waste layer, generally 0-15 feet bgs.

COPC = chemical of potential concern

Table 6-7
Summary of Site vs. Background Statistical Analyses - SWMU 49

Inorganic Constituent	Data Distribution [a]		Site > Background? [b]	Basis [b]
	SWMU-49	Background		
Surface Soil (0 - 0.5 feet)				
Aluminum	Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Antimony	Not COPC [c]	All nondetect	-- [c]	--
Arsenic	Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Barium	Not COPC	Normal	--	--
Beryllium	Not COPC	Not Normal	--	--
Cadmium	Not COPC	Detects < 3	--	--
Calcium	Not COPC	Not Normal	--	--
Chromium	Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Cobalt	Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Copper	Not COPC	Not Normal	--	--
Iron	Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Lead	Not Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Magnesium	Not COPC	Not Normal	--	--
Manganese	Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Mercury	Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Nickel	Not COPC	Not Normal	--	--
Potassium	Not COPC	Not Normal	--	--
Selenium	Not Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Thallium	Detects < 3 [d]	Not Normal	No	Wilcoxon Mann Whitney Test
Vanadium	Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Zinc	Not COPC	Not Normal	--	--
Total Soil [e]				
Aluminum	Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Antimony	Not COPC	All nondetect	--	--
Arsenic	Not Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Barium	Not COPC	Not Normal	--	--
Beryllium	Not COPC	Not Normal	--	--
Cadmium	Not COPC	Not Normal	--	--
Calcium	Not COPC	Not Normal	--	--
Chromium	Normal	Normal	No	T-test
Cobalt	Normal	Not Normal	**Yes**	Wilcoxon Mann Whitney Test
Copper	Not COPC	Not Normal	--	--
Iron	Normal	Normal	No	T-test
Lead	Not COPC	Not Normal	--	--
Magnesium	Not COPC	Not Normal	--	--
Manganese	Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Mercury	Not COPC	Not Normal	--	--
Nickel	Not COPC	Not Normal	--	--
Potassium	Not COPC	Not Normal	--	--
Selenium	Not COPC	Detects < 3	--	--
Thallium	Not Normal	Not Normal	No	Wilcoxon Mann Whitney Test
Vanadium	Not Normal	Normal	No	Wilcoxon Mann Whitney Test
Zinc	Not COPC	Not Normal	--	--

a Background distribution as determined by ProUCL version 4.0 Goodness-of-Fit test, NDs included (as DL/2), Shapiro-Wilks test, if available otherwise Lillefors test results used. Details in **Appendix E-10**. Site distribution as determined by ProUCL version 4.0 95% UCL calculation.

b) Two sample (population) hypothesis testing, two-sided test, using ProUCL version 4.0.
"Without ND" option used if 100% detects, otherwise "With ND" option employed.
T-test used if both site and background data sets had normal distributions, otherwise WMW test used.
95% confidence level selected. Details in **Appendix E-10**.

c) No statistical results presented, as chemical not COPC/COPEC.

d) If detects < 3, data distribution could not be determined.

e) Total soil = samples collected from 0 to 15 feet bgs.

WMW Test = Wilcoxon Mann Whitney test
COPC = chemical of potential concern

related (i.e., B-qualified) data in the data set. Although B-qualified were eliminated, however, the amount of B-qualified data in the data set was low.

Another uncertainty associated with sampling and analysis concerns the inclusion of chemicals that are potentially present in the environment due to anthropogenic sources. For example, dioxins are considered ubiquitous in soil from anthropogenic sources, such as combustion and incineration of municipal waste, coal, wood, and fuel. If such chemicals are not site related, the risks associated with the site may be overestimated. This uncertainty may have a low-to-moderate effect on overestimating risks.

6.5.2 Selection of Chemicals for Evaluation

A comparison of maximum detected chemical concentrations to USEPA RSLs was conducted for surface soil, total soil, and groundwater. Chemicals with maximum concentrations below their respective RSLs were not carried through the assessment. It is unlikely that this risk-based screening excluded chemicals that should be included, based on the conservative exposure assumptions and conservatively derived toxicity criteria that are the basis of the RSLs. Although following this methodology does not provide a quantitative risk estimate for every chemical, it focuses the assessment on the chemicals accounting for the greatest risks (i.e., chemicals whose maximum concentrations are above their respective RSLs) and the cumulative risk estimates would not be expected to be significantly greater. As presented on the non-detect method detection limit (MDL) screening tables, the maximum MDL was greater than the adjusted RSLs for several chemicals in soil and groundwater; therefore, the site-related risks and hazards could be underestimated for the risk assessments due to inadequate detection limits. The results for the evaluations of non-detects at SWMUs 48 and 49 are discussed in the following sections.

It is noted that USEPA updates the RSLs approximately every six months. At the time the screening was conducted for this HHRA, the November 2011 RSLs were in effect. The updated RSL tables were released on May 3, 2012. Toxicity values changed for two constituents detected at SWMU 48: TCDD TE in surface soil, total soil, and groundwater, and PCE in groundwater. For SWMU 49, toxicity values changed for three constituents: TCDD TE in surface soil, total soil, and groundwater; methylene chloride in total soil; and PCE in groundwater. As a result, the April 2012 RSLs for methylene chloride and PCE are now higher (and less conservative) than the corresponding November 2011 RSLs. The RSLs for TCDD TE were not affected because only the noncancer toxicity values changed. Therefore, the updates to the RSL tables do not impact the conclusions of the HHRA.

The reporting limits for chemicals that were not detected in surface soil, total soil, and groundwater at SWMU 48 were compared with RSLs in **Appendix E-1, Tables E.1-3, E.1-5, and E.1-7**, respectively. As shown in **Table E.1-3,** reporting limits in surface soil were greater than RSLs for 10 of 139 constituents (7 percent). These constituents include 3,3’-dichlorobenzidine; 4,6-dinitro-o-cresol; acrylonitrile; Anicon B (MCPP); bis(2-chloroethyl)ether; MCPA; n-nitroso-di-n-propylamine; PCP; vinyl chloride; and antimony. With the exception of PCP, vinyl chloride, and antimony, these constituents have neither been used at SWMU 48 nor detected at other sites at RFAAP. PCP was selected as a COPC in groundwater. While the maximum reporting limit for PCP (0.91 mg/kg) was slightly greater than the RSL of 0.89 mg/kg, the lower reporting limit in the range (of 0.76 mg/kg) was less than the RSL. Therefore, the cancer risk associated with concentrations at the reporting limit would likely be at the lower end of the target risk range. Vinyl chloride is a breakdown product of PCE and TCE. These constituents have been detected in groundwater at the site. While the maximum reporting limit for vinyl chloride (1.8 mg/kg) was greater than the RSL of 0.06 mg/kg, the lower reporting limit in the range (of 0.0048 mg/kg) was less than the RSL. Because vinyl chloride was not detected in samples at the lower limit, vinyl chloride is not likely to be present at the site. Although the maximum reporting limit for antimony (19.6 mg/kg) was above the adjusted RSL of 3.1 mg/kg (i.e., RSL adjusted by one-tenth to account for cumulative effects from multiple chemicals), this concentration is below the unadjusted RSL for antimony of 31 mg/kg. For 15 of 139 constituents (11 percent) in surface soil, there were no RSLs for comparison. These constituents include 4-bromophenoxybenzene; 4-chlorophenyl phenylether; carbazole; cis-1,3-dichloro-1-propylene; delta-BHC; dichloroprop; dimethylphthalate; di-octylphthalate; m-dichlorobenzene; m-nitroanaline; o-nitrophenol; p-nitrophenol; TPH; trans-1,3-dichloropropene; and sodium. Sodium is an essential nutrient. The maximum reporting limit is 22 mg/kg and is unlikely to pose a health risk in soil at this level. The potential toxicity of TPH is more specifically represented by individual components such as the PAHs. The remaining chemicals are not known to be associated with past disposal at SWMU 48.

As shown in **Table E.1-5**, reporting limits in total soil were above RSLs for 36 of 160 constituents (22.5 percent). These constituents include 1,1,2-trichloroethane; 1,2,3-trichloropropene; 3,3’-dichlorobenzidine; 4,4’-DDE; 4,6-dinitro-o-cresol; acrolein; acrylonitrile; aldrin; alpha-BHC; alpha-chlordane; Anicon B (MCPP); Aroclor 1016; Aroclor 1221; Aroclor 1232; Aroclor 1242; Aroclor 1248; Aroclor 1260; benzidine; beta-BHC; endrin; endrin ketone; bis(2-chloroethyl)ether; 1,2-dibromo-3-chloropropane (DBCP); dieldrin; gamma-chlordane; heptachlor; heptachlor epoxide; hexachlorobenzene; lindane; MCPA; n-nitrosodimethylamine; n-nitroso-di-n-propylamine; p-chloroaniline; PCP; toxaphene; and vinyl chloride.

Although there is no information that indicates PCP has been used at SWMU 48, this compound was identified as COPCs for groundwater in the study area. The maximum reporting limit for PCP (6.0 mg/kg) in soil was above the RSL (0.76 mg/kg); however, the lowest reporting limit (0.76 mg/kg) was below the RSL. Vinyl chloride is a breakdown product of PCE and TCE, which have been detected in groundwater at the site. Similar to surface soil, the maximum reporting limit for vinyl chloride (1.8 mg/kg) was greater than the RSL of 0.06 mg/kg. The lower reporting limit in the range (of 0.0048 mg/kg), however, was less than the RSL for vinyl chloride. Because vinyl chloride was not detected in samples at the lower limit, vinyl chloride is not likely to be present at the site. The other chemicals are not likely to have been associated with past disposal at SWMU 48. For 20 of 160 constituents (12.5 percent) in total soil, there were no RSLs for comparison. These constituents included: 1,1-dichloropropene; 2,2-dichloropropane; 2-chloroethyl vinyl ether; 3,5-dinitroaniline; 4-bromophenoxybenzene; 4-chlorophenyl phenylether; carbazole; cis-1,3-dichloro-1-propylene; delta-BHC; dichloroprop; dimethylphthalate; di-octylphthalate; m-dichlorobenzene; m-nitroanaline; o-nitrophenol; p-nitrophenol; sec-butylbenzene; tert-butylbenzene; TPH; and trans-1,3-dichloropropene. Several of these constituents were similar to those identified for surface soil. With the possible exception of TPH, these chemicals are not known to be associated with past disposal at SWMU 48.

As shown in **Table E.1-7**, reporting limits in groundwater were greater than RSLs for 76 of 175 constituents (43 percent). For 22 of 175constituents (12.5 percent) in groundwater, there were no RSLs for comparison. Some of these constituents could potentially be site related. It is assumed, however, groundwater exposures at SWMU 48 involve limited exposure frequency and exposure duration for maintenance and industrial workers. In addition, while a residential scenario has been included for completeness, it is unlikely that SWMU 48 groundwater will be used for residential purposes in the future.

The reporting limits for chemicals that were not detected in surface soil, total soil, and groundwater at SWMU 49 were compared with RSLs in **Appendix E-2, Tables E.2-3, E.2-5, and E.2-7**, respectively. As shown in **Table E.2-3,** the reporting limits for 9 of 131 constituents (7 percent) in surface soil were greater than their RSLs. These constituents included: 2,4-DNT; 3,3’-dichlorobenzidine; 4,6-dinitro-o-cresol; antimony; MCPA; MCPP; nitroglycerin; n-nitroso-di-n-propylamine; and PCP. The explosive, 2,4-DNT, was detected in total soil at SWMU 48. Although the maximum reporting limit for 2,4-DNT (1.4 mg/kg) was above the RSL of 0.72 mg/kg, the RSL is based on a risk of 1E-06. The reporting limit would be below the RSL based on a risk of 1E-05 (7.2 mg/kg). PCP was selected as a COPC in groundwater. While the maximum reporting limit for PCP (0.97 mg/kg) was slightly greater than the RSL of 0.89 mg/kg, the lower reporting limit in the range (of 0.76 mg/kg) was less than the RSL. For 16 of 131 constituents (12 percent) in surface soil, there were no RSLs for comparison. These constituents include 1,3-dichlorobenzene; 2-nitrophenol; 3&4-methylphenol; 3-nitroaniline; 4-bromophenyl phenylether; 4-chlorophenyl phenylether; 4-nitrophenol; carbazole; cis-1,3-dichloro-1-propene; delta-BHC; dichloroprop; dimethylphthalate; di-octylphthalate; p-chloro-m-cresol; sodium; and trans-1,3-dichloropropene. Sodium is an essential nutrient. The range of reporting limits is 17 to 78 mg/kg. These levels in soil are unlikely to pose a health risk. The remaining chemicals are not likely to be associated with past disposal at SWMU 49.

As shown in **Table E.2-5**, reporting limits in total soil were above RSLs for 16 of 143 constituents (11 percent). These constituents include 1,2,3-trichloropropane; 1,2-dibromo-3-chloropropane; 1,2-diphenylhydrazine; 2,4-DNT; 3,3’-dichlorobenzidine; 4,6-dinitro-o-cresol; antimony; bis(2-chloroethyl)ether; hexachlorobenzene; MCPA; MCPP; nitroglycerin; n-nitroso-di-n-propylamine; p-chloroaniline; PCP; and toxaphene. With the exception of 2,4-DNT and antimony, these constituents are unlikely to have been disposed at SWMU 49. Although the maximum reporting limit for 2,4-DNT (1.4 mg/kg) was slightly above the RSL of 0.72 mg/kg, the RSL is based on a risk of 1E-06. Therefore, the cancer risk associated with concentrations at the reporting limit would be at the lower end of the target risk range. The maximum reporting limit for antimony (19.6 mg/kg) was above the adjusted RSL of 3.1 mg/kg; however, this concentration is below the unadjusted RSL for antimony of 31 mg/kg. PCP was a COPC for groundwater in the study area. The maximum reporting limit for PCP (10.0 mg/kg) in soil was above the RSL (0.89 mg/kg) at a 1E-06 risk level. At a risk level of 1E-05 (8.9 mg/kg), the reporting limit would still be above the RSL. However, this concentration would be well within the target risk range of 1E-06 to 1E-04. For 19 of 143 constituents (13 percent) in total soil, there were no RSLs for comparison. These constituents included 1,1-dichloropropene; 1,3-dichlorobenzene; 2,2-dichloropropane; 2-chloroethyl vinyl ether; 2-nitrophenol; 3&4-methylphenol; 3-nitroaniline; 4-bromophenyl phenyl ether; chlorophenyl phenyl ether; 4-nitrophenol; carbazole; cis-1,3-dichloro-1-propene; delta-BHC; dichloroprop; dimethylphthalate; di-n-octylphthalate; sec-butylbenzene; tert-butylbenzene; and trans-1,3-dichloropropene. These chemicals are not known to be associated with past disposal at SWMU 49.

As shown in **Table E.2-7**, reporting limits in groundwater were above RSLs for 76 of 175 constituents (43 percent). For 22 of 175 constituents (12.5 percent) in groundwater, there were no RSLs for comparison. Some of these constituents could potentially be site related. It is assumed that groundwater exposures at SWMU 49 involve limited exposure frequency and exposure duration for maintenance and industrial workers. In addition, while a residential scenario has been included for completeness, it is unlikely that SWMU 49 groundwater will be used for residential purposes in the future.

In general, these chemicals, if present in surface soil, total soil, and groundwater, could contribute additional risk and hazard at SWMUs 48 and 49. Therefore, risks and hazards associated with the site may be underestimated. Even if the risk and hazard were underestimated for groundwater, however, it is noted that the risk estimate is already above 1E-04 and the HI is well above 1.

Background concentrations of metals in soil at RFAAP have been characterized and are used in statistical comparisons to site soil to evaluate whether concentrations of metals detected at SWMUs 48 and 49 are consistently higher or lower than background. However, the background data obtained may not fully characterize naturally-occurring metals level in off-site fill used at the site. Uncertainties associated with the use of these data may lead to a low-to-moderate overestimation or underestimation of surface and total soil risks due to metals.

Screening criteria are derived from RDAs for essential human dietary minerals, trace elements, and electrolytes that are potentially toxic at very high doses (i.e., calcium, magnesium, potassium, and sodium). None of these elements were selected as COPCs in soil. Omitting these essential human nutrients from further evaluation is expected to have a low effect on risk and hazard estimates. Calcium, magnesium, and sodium were identified as COPCs in groundwater and were retained in the HHRA.

6.5.3 Exposure Assessment

The primary areas of uncertainty affecting exposure parameter estimation involve the assumptions regarding exposure pathways, the estimation of EPCs, and the exposure parameters used to estimate chemical doses. An underlying assumption in the HHRA is that individuals at the site would engage in activities that result in exposures via each selected pathway. For example, it was assumed that maintenance workers engage in regular activities (once a week) under current and future land use conditions resulting in exposure to COPCs. This assumption is conservative, in that it is more likely that the activity patterns occur occasionally.

For SWMU 48, the PEFs for the maintenance workers, industrial workers, and construction workers were based on the actual size of the site (1.009 acres). Per USEPA guidance, the PEFs for the residents were based on a 0.5-acre residential lot. Because the sampling plan was based on approximately 1 acre, the PEF values likely overestimate the inhalation risk and hazard for the residents. SWMU 49 is 0.111 acre in size; however, the PEFs for the workers and residents were based on 0.5 acres because the factors for the Q/C calculations were derived for sites between 0.5 to 500 acres (USEPA, 2002b). As a result, the risks and hazards for the inhalation pathway could be overestimated for SWMU 49. The potential overestimation would not affect the conclusions for either site.

The non-cancer hazard estimates for the inhalation of dust emissions by the construction worker receptor are based on the construction worker PEF calculation. Because future plans for construction or excavation at SWMUs 48 and 49 are not known, assumptions regarding the duration of construction activities and type and number of construction vehicles were based on the acreage of each site. Although the inhalation cancer risk/non-cancer hazard estimates could be overestimated, the calculated risks and hazards were below the target risk range and HI. In addition, there is generally a higher level of uncertainty associated with the use of modeled concentrations (i.e., PEF) than in the use of measured concentrations if valid measurement data are available for the exposure medium and exposure location.

In establishing EPCs, the concentrations of chemicals in the media evaluated are assumed to remain constant over time. Depending on the properties of the chemical and the media in which it was detected, this assumption could overestimate or underestimate risks, depending on the degree of chemical transport to other media or the rate and extent a chemical degrades over time. For example, the biodegradation of PCE and TCE could result in the formation of vinyl chloride over time. Vinyl chloride is classified as a known human carcinogen. Therefore, the cancer risks associated with exposures to groundwater may be underestimated.

When calculating EPCs from sample data using ProUCL, non-detect results are coded as “zeroes.” As indicated in the ProUCL output (**Appendices E-4 and E-5**), summary statistics, such as the arithmetic mean, are based on detected values only. For calculation of the 95% UCL of the mean, the program substitutes surrogate values for the detection limits. Approaches which substitute values for non-detected chemical concentrations are associated with uncertainty, because chemicals that were not detected at the specified sample MDL may be absent from the medium or may be present at a concentration below the sample MDL. Furthermore, only the detected concentrations in each data set are used to determine the distribution of the data. For data sets with non-detects, the uncertainty associated with the distribution of the data could result in an over-estimation of the EPC. It is also noted that there were two versions of ProUCL used in this HHRA: ProUCL 4.00.02 (USEPA, 2007a) and 4.1.00 (USEPA, 2010a). Most of the differences have involved upgraded or expanded capabilities. Differences in 95% UCL values would not be expected to vary enough to change the overall results of the HHRA.

The 95% UCL is used as the EPC for each medium if at least eight to ten samples are available. The ProUCL software typically gives a warning when data sets are too small (sample size < 10), which suggests that the 95% UCL values could be unreliable. If the 95% UCL is greater than the maximum detected value or if fewer than five samples are available, the maximum is conservatively used as a default EPC. Using a value that is based on one sampling location (i.e., the maximum) has associated uncertainty and it adds a great deal of conservatism to the assessment. The 95% UCL was used as the EPC for each chemical in soil. Therefore, the cancer risk/non-cancer hazard estimates are not likely to be biased high. The EPCs for groundwater, however, were based on maximum values, which could result in an overestimation of risk or hazard. The exposure parameters used to describe the extent, frequency, and duration of exposure is associated with uncertainty. Actual risks for individuals within an exposed population may differ from those predicted, depending upon their actual intake rates (e.g., soil ingestion rates), nutritional status, or body weight. Exposure assumptions were selected to produce an upper-bound estimate of exposure in accordance with USEPA guidelines regarding evaluation of potential exposures at Superfund sites (e.g., exposures were assumed to occur for 25 years for workers). In addition, many USEPA (1991b) default exposure parameters are highly conservative and are based on risk management interpretations of limited data. For example, although current USEPA guidance recommends default soil ingestion rates of

100 mg/day for individuals over 6 years of age, other studies, such as Calabrese et al. (1990), have shown that the USEPA default soil ingestion rate of 100 mg/day is likely to greatly overestimate adult exposures and risks. In addition, chemicals in soil are assumed 100% bioavailable; this assumes that ingested chemicals present in a soil matrix are absorbed through the gastrointestinal (GI) tract, which is unlikely due to the affinity of contaminants for soil particles. Therefore, based on the conservative exposure assumptions used in the HHRA, exposures and estimated potential risks are likely to be overestimated for the ingestion of soil pathways.

Evaluation of the dermal absorption exposure pathway is affected by uncertainties in dermal exposure parameters. For example, there is uncertainty associated with the exposed skin surface areas used, since the choice of exposed body parts could slightly overestimate or underestimate risks. Uncertainties that are more significant are associated with the selection and use of dermal absorption factors. For this HHRA, the dermal absorption factors and calculations were based on USEPA Region III guidance, USEPA's *RAGS: Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA, 2004a). Very limited information is available on dermal absorption of chemicals from contacted soil under environmental conditions. In fact, there are not actual human epidemiological data to support the hypothesis that absorption of soil bound compounds under exposure conditions is a complete route of exposure. For example, the Public Health Statements from the ATSDR (1992, 2000, 2006) indicate that metals such as aluminum, manganese, and vanadium are not known to result in human health effects by dermal absorption because very little can enter the body through the skin under normal circumstances (i.e., without exposure to very high concentrations for long periods or exposure to skin that is damaged). Therefore, using the dermal absorption factors to evaluate dermal absorption exposures to soil may result in an overestimation of risks.

For exposures to COPCs in groundwater via dermal absorption, the USEPA's dermal guidance (USEPA, 2004a) cautions that the procedures for estimating dermal dose from water contact are very new. The dermal permeability estimates are probably the most uncertain of the parameters in the dermal dose equation. The equation used to calculate the term, DA_{event}, is based on a regression model that predicts the water permeability coefficient for organics. Statistical analysis of the regression equation provides the range of octanol/water partition coefficients (K_{ow}) and MW where this regression model could be used to predict permeability coefficients (Effective Prediction Domain or EPD). For chemicals outside the EPD, such as dioxins, a model for predicting the fraction absorbed dose (FA) is proposed for chemicals with a high K_{ow}, taking into account the balance between the increased lag time of these chemicals in the stratum corneum and the desquamation of skin during the absorption process. The consequence is a net decrease in total systemic absorption. Therefore, by applying an FA of 0.5 to the calculation of DA_{event}, the risk is 50 percent lower than it would have been calculated without accounting for the EPD. In addition, the guidance (USEPA, 2004a) notes that particulate-bound chemicals in aqueous medium (e.g., suspended soil particles) would be considered much less bioavailable for dermal absorption due to inefficient adsorption of suspended particles onto the skin surface and a slower rate of absorption into the skin. Because dioxins adsorb to soil, the detection of dioxins in SWMU 48 and SWMU 49 groundwater samples is possibly attributable to the presence of particulates. Therefore, risks due to dermal absorption could potentially be overestimated for the dioxins. Conversely, the permeability coefficients for the halogenated compounds (CT, PCE, TCE) are likely to be underestimated. Because halogenated chemicals have a lower ratio of molar volume relative to their MW than hydrocarbons (due to the relatively weighty halogen atom), the K_p correlation based on MW of hydrocarbons will tend to underestimate permeability coefficients for halogenated organic chemicals (USEPA, 2004a).

Several models were used to evaluate exposure scenarios that involve the volatilization of COPCs from groundwater to air. These models include: the ASTM Model for volatilization from groundwater to ambient air, the Johnson and Ettinger Model for migration of VOCs from groundwater into indoor air, the VDEQ Trench Model for volatilization of VOCs from groundwater into a construction/utility trench, and the Foster-Chrostowski Shower Model for volatilization of VOCs from groundwater into shower air. The uncertainties associated with these models are discussed in the following sections.

The volatilization model outlined in ASTM RBCA Guidance (ASTM, 1995) was used to estimate the concentration of VOCs in ambient or outdoor air that originate from dissolved hydrocarbons in groundwater located some distance below ground surface (**Appendix E-1, Table E.1-27** and **Appendix E-2, Table E.2-27**). This model calculates a representative concentration in air based on the following assumptions:

- A constant dissolved concentration in groundwater.
- Linear equilibrium partitioning between the dissolved chemicals and groundwater and chemical vapors in the groundwater table.
- Steady-state vapor- and liquid-phase diffusion through the capillary fringe and vadose zones to ground surface.
- No loss of chemical as it diffuses towards the ground surface (i.e., no biodegradation).
- Steady well-mixed atmospheric dispersion for the emanating vapors within the breathing zone as modeled by a “box model” for air dispersion.

A number of uncertainties associated with this model would likely result in an overestimation of risk and hazard in this HHRA. First, the maximum concentrations of chlorinated solvents in groundwater were assumed to be the constant dissolved concentration. Use of the maximum value may overestimate risk and hazard. Second, it is assumed that there is no loss of chemical due to biodegradation over time. This assumption is especially conservative with respect to exposure for the industrial worker scenario, which is based on an exposure duration of 25 years. Third, it is assumed that vapor concentrations remain constant over the duration of exposures and that all inhaled chemicals are absorbed.

The ASTM model also considers wind speed, mixing height, depth to groundwater, and diffusion coefficients in air and water. Uncertainty based on mechanisms such as partitioning, diffusion, and dispersion would be dependent on chemical-specific and site-specific conditions and could result in either over- or underestimation of chemical concentrations at SWMUs 48 and 49. The depth to groundwater assumed for the calculations at SWMU 48 was based on the average depth to groundwater [69.59 ft or 2,121 centimeters (cm)]. The shallowest depth to groundwater measured at SWMU 48 has been measured at 48.24 ft (or 1,470 cm). Similarly, the depth to groundwater assumed for the calculations at SWMU 49 was based on the average depth to groundwater (109.71 ft or 3,344 cm). The shallowest depth to groundwater measured at SWMU 49 has been measured at 97.6 ft (or 2,975 cm). Because groundwater is relatively deep in the study area, concentrations of VOCs migrating from groundwater to the ground surface over time would likely be negligible.

The Johnson and Ettinger Model (1991; USEPA, 2004b) was used to estimate indoor air concentrations of volatiles migrating from groundwater through the soil and into potential future on-site and off-site residences and buildings (**Appendix E-1**, **Table E.1-28** and **Appendix E-2, Table E.2-28**). As acknowledged in the *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* (USEPA, 2004b), the Johnson and Ettinger Model "…was developed for use as an SL model and consequently is based on a number of simplifying assumptions regarding contaminant distribution and occurrence, subsurface characteristics, transport mechanisms, and building construction." Limitations and assumptions associated with the Johnson and Ettinger Model are described in the *User's Guide* (USEPA, 2004b). These include:

Contaminant Distribution and Occurrence

- No contaminant free-liquid/precipitate phase present.
- Contaminant is homogeneously distributed within the zone of contamination.
- No contaminant sources or sinks in the building.
- Equilibrium partitioning at contaminant source.
- Chemical or biological transformations are not significant (i.e., the model will predict more intrusion).

For the SWMUs 48 and 49 HHRA, the maximum concentrations of volatile COPCs (CT; 1,1-DCA; 1,2-DCA; cis-1,2-DCE; PCE; and TCE) in groundwater were conservatively used as the input for the groundwater concentrations in the model. Although homogeneous distribution is assumed, the maximum concentration is not likely to be representative of the chemical concentrations across the site. Also, neither sorption nor biodegradation is accounted for in the transport of vapor from the source to the base of the building. Based on these factors, the risk and hazard associated with inhalation of COPCs in indoor air are likely to be overestimated.

Subsurface Characteristics

- Soil is homogeneous within any horizontal plane.
- All soil properties in any horizontal plane are homogeneous.
- The top of the capillary fringe must be below the bottom of the building floor in contact with the soil.
- The USEPA version of the Johnson and Ettinger Model assumes the capillary fringe is uncontaminated.

Because the water level is below the rock layer in the study area, there is no capillary fringe. Due to the presence of the rock layer, the soil and the soil properties in any horizontal plane are not homogeneous. The *User's Guide* (USEPA, 2004b) acknowledges that "…In theory the limitations are readily conceptualized, but in practice the presence of these limiting conditions may be difficult to verify even when extensive characterization data are available." Although there are a number of limitations associated with the Johnson and Ettinger Model, it is likely that similar limitations are encountered at other RCRA and Superfund sites. The results of the risk assessments at RFAAP as well as others would be more uncertain if a less accepted or documented model was used.

Transport Mechanisms

- Transport is one-dimensional.
- There are two separate flow zones: diffusive and convective.
- Vapor-phase diffusion is the dominant mechanism for transporting contaminant vapors from contaminant sources located away from the foundation to the soil region near the foundation.
- There is a straight-line gradient in the diffusive flow zone.
- Diffusion through soil moisture is insignificant.
- Convective transport is likely to be most significant in the region very close to the basement or the foundation, and vapor velocities decrease rapidly with increasing distance from a structure.
- Vapor flow is described by Darcy’s Law (i.e., porous media flow assumption).
- Steady state convection is assumed (i.e., the flow is not affected by barometric pressure or infiltration). Convective flow near the foundation is uniform (i.e., flow rate does not vary by location).
- Convective velocity through cracks or porous medium is uniform.
- Significant convective transport only occurs in the vapor phase.
- All contaminant vapors originating from directly below the basement will enter the basement, unless the floor and walls are perfect barriers. Contaminant vapors enter structures primarily through cracks and openings in the walls and foundation.

Because most of the inputs to the model are not collected during a typical site characterization, conservative inputs were estimated or inferred from available data and other non-site-specific sources of information. In addition, because there are currently no structures at or near SWMU 48 or SWMU 49, the default values for a typical residential building were used to represent the building characteristics in the model. It was also assumed that the building would be constructed with a basement and would be located in an area with the shallowest depth to groundwater. The shallowest depths to groundwater are (48.24 ft at SWMU 48 and 97.6 ft at SWMU 49). It is assumed that vapor velocities decrease rapidly with increasing distance from a structure. These assumptions contribute to a conservative estimate of hypothetical VOC concentrations in building air at SWMUs 48 and 49.

As stated in *Section 6.2.3*, USEPA has not developed a standardized model for estimating concentrations of airborne VOCs released from groundwater during construction or excavation activities. Therefore, VDEQ’s VRP trench model was used in this HHRA (**Appendix E-1**, **Table E.1-29** and **Appendix E-2, Table E.2-29**). Due to several conservative assumptions used in VDEQ’s trench model, risks and hazards due to potential exposures to groundwater during the hypothetical excavation of a construction/utility trench are likely to be overestimated. The uncertainties associated with this model include:

- The maximum concentration VOCs (CT; 1,1-DCA; 1,2-DCA; cis-1,2-DCE; PCE; and TCE) in SWMU 48 and SWMU 49 groundwater were used to estimate exposures to COPCs in ambient air in a construction/utility trench. The use of the maximum value is likely to overestimate risk and hazard. In addition, the model does not account for the dilution, dissipation, or degradation of VOCs over time.

- The depth of the trench was set at VDEQ's default value at 8 ft. The depths to groundwater at the shallowest points of SWMUs 48 and 49 are 48.24 and 97.6 ft, respectively. Migration of VOCs from these depths is unlikely.
- To be consistent with the other excavation/construction exposures in this HHRA, an exposure frequency of 250 days/year and exposure duration of 1 year were assumed for a worker in the trench. The default value for exposure time in the trench model was 4 hours per each day of excavation/construction work. As a practical matter, it is unlikely that the same individual(s) would work in a trench at SWMUs 48 and 49 for 4 hours each day for 1 year.

The Foster-Chrostowski (1987, 2003) shower room model was used to estimate the EPC of PCE in air due to volatilization from groundwater during showering and applied to an adult resident (**Appendix E-1**, **Table E.1-30** and **Appendix E-2, Table E.2-30**). Although VOCs may volatilize into indoor air from most typical household uses of groundwater, showering likely represents the upper-bound for exposure. The warm water temperature of a shower facilitates volatilization and the receptor is confined in a relatively small space with the released VOCs. The showering scenario and the characteristics of a typical shower room have been studied sufficiently to permit the estimation of shower room air concentrations of VOCs.

There are several factors that contribute to the potential uncertainty of the results of the shower model (Foster and Chrostowski, 2003). These factors include chemical-specific input parameters (e.g., Henry's Law constants), calculation of mass-transfer coefficients, and indoor air compartment flow rates. The calculation of mass transfer coefficients is an important component of modeling volatilization and requires information on chemical-specific properties as well as the interfacial area across which volatilization can occur. Mass transfer can be affected by different water characteristics, such as water flow rate, shower nozzle type, droplet size, distribution, and water temperature. There are also uncertainties associated with the choice of the flow. For example, a plug flow model represents the mass transfer from a flowing water supply, such as a shower. Other model uncertainties include the exclusion of some sources of VOC volatilization into indoor air other than the water droplet in the shower. The Foster-Chrostowski model does not address volatilization from water after it has impacted nearby surfaces or as it drains from the floor of the shower. As a result, risk or hazard could be underestimated.

Finally, although the shower model focuses on indoor air concentrations associated with showering, it does not address other indoor air from uses of water such as bathing, air humidifiers, dish washing machines, clothes washing machines, toilets, and sinks. Therefore, with respect to VOCs in indoor air from all potential household uses, risk and hazard are likely to be underestimated.

6.5.4 Toxicological Data

The HHRA relies on USEPA-derived or USEPA-endorsed dose response criteria. These health effects criteria are conservative and are designed to be protective of sensitive subpopulations. The health criteria used to evaluate long-term exposures, such as RfDs or CSFs, are based on concepts and assumptions that bias an evaluation in the direction of overestimation of health risk. As USEPA notes in its *Guidelines for Carcinogenic Risk Assessment* (USEPA, 1986), there are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility, human populations are variable with respect to genetic constitution, diet, occupational and home environment, activity patterns, and other cultural factors.

These uncertainties are compensated for using upper-bound 95% UCLs for CSFs (carcinogens), and safety factors for RfDs (non-carcinogens). The assumptions used here provide a rough but plausible estimate of the upper limit of risk; in other words, it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably lower, even approaching zero. More refined modeling in the area of dose response calculation (e.g., using maximum likelihood dose response values rather than the 95% UCL) would be expected to substantially lower the final risk.

USEPA has determined that TCE acts via a mutagenic mode of action (MOA) (USEPA, 2012a). This compound was identified as a COPC in groundwater. Risks for MOA compounds can be estimated by applying age-dependent adjustment factors (ADAFs) to account for early-life susceptibility to cancer. The use of ADAFs results in higher cancer risks; therefore, the risks calculated for TCE is likely to be under-estimated. However, given that the cancer risks associated with groundwater at SWMUs 48 and 49 already exceeds 1E-04 for the industrial worker, lifetime resident, and child resident, the application of ADAFs would not change the conclusions of the HHRA.

For dermal absorption exposure pathways, the absence of dermal toxicity criteria necessitates the use of oral toxicity data. To calculate risk estimates for the dermal absorption pathway, absorbed dermal absorption doses are combined with oral toxicity values (also discussed above in *Section 6.3*). Oral toxicity values, which are typically expressed in terms of potential (or administered) doses, should be adjusted when assessing dermal absorption doses, which are expressed as internal (or absorbed) doses. In this assessment, absolute oral absorption factors that reflect the toxicity study conditions were used to modify the oral toxicity criteria. For those chemicals lacking sufficient information, a default oral absorption factor of 1.0 was used. The risk estimates for the dermal absorption pathways may be overestimated or underestimated, depending on how the values used in the HHRA reflect the difference between the oral and dermal routes.

Inhalation toxicity criteria are unavailable for many of the COPCs. This HHRA does not use oral-based toxicity criteria to estimate risks from inhalation exposure because of the following uncertainties associated with such a substitution:

- Many contaminants show portal-of-entry toxicity - that is, adverse health effects occur primarily at the tissue site at which the chemical is introduced into the body (e.g., GI tract, lung, or skin).
- Physiological and anatomical differences between the GI tract and respiratory systems invalidate a cross-route quantitative risk extrapolation. The small intestine of humans contains a very large surface area that readily absorbs most compounds by passive diffusion (Klaasen, 1986). The oral absorption of a few compounds, such as iron, is an energy-dependent (active-transport) process; wherein, the absorption rate is proportional to the body’s current need for iron.

- The rate and extent of pulmonary absorption are much more complex and depend on such factors as particle size distribution of the airborne toxicant and blood-gas solubility of the toxicant (Klaasen, 1986). Particles with median aerodynamic diameters of approximately 1 micrometer or less are absorbed by the alveolar region of the human lung. Larger particles deposit in the tracheobronchial or nasopharyngeal regions where they are cleared by mucociliary mechanisms and subsequently swallowed or physically removed and exhaled. Therefore, pulmonary absorption is more highly dependent on the physiochemical properties of the material than oral absorption.
- Because highly soluble gases (e.g., chloroform) are more rapidly absorbed into the blood than poorly soluble gases (e.g., ethylene), they take much longer to reach equilibrium. Thus, the inhalation absorption rate of a gas is more dependent on blood solubility than the oral absorption rate of the same substance administered as a liquid.
- Human inhalation risk estimates based on oral toxicity data in subhuman species are distorted by both route-to-route extrapolation and interspecies extrapolation. For example, the rodent GI tract, which includes a structurally unique forestomach, is anatomically and functionally distinct from the human lung, which contains a very large alveolar surface area for extensive absorption. The rate and extent of absorption across these distinct physiological systems are not alike.

In addition, for inhalation exposure to substances present as dusts, vapors, gases, or airborne particulate matter, dose extrapolation is far more complex, and therefore associated with uncertainty. The major confounding factors that prohibit a direct dose extrapolation of an inhaled toxicant are the following:

- Over 40 functionally different cell types in the lung - the distribution, consequent metabolic reactions, and air exchange rates vary widely across species.
- Differential concentration and activity of the detoxifying protein glutathione.
- Interspecies and intraspecies differences in the ability to repair pulmonary cell damage, and to clear toxic contaminants and immune complexes from the respiratory tract. For example, species vary in the ability to activate macrophages - nonspecific immune cells that can both protect the inner lining of the respiratory system and, at high concentrations, damage healthy tissues.
- Anatomical variations in the respiratory pathway, which affect both absorption rates and time to reach steady-state blood levels.
- Sensitivity to solubility and concentration variables; because of metabolic saturation (i.e., the exhaustion of normal metabolic activity caused by exposure to high concentrations), highly soluble contaminants deviate from first-order kinetics - which makes it difficult to predict the rates and extent of biotransformation and detoxification reactions. Furthermore, intermittent inhalation exposure to highly blood-soluble chemicals results in bioaccumulation in fat tissue because of the insufficient time between exposure sessions for complete clearance of the contaminant. Such slow release from the fat compartment to other body tissues can result in toxicological and metabolic effects that are difficult to assess and vary across species.

For chemicals without IRIS toxicity criteria, provisional toxicity criteria were used where available (**Appendix E-1, Tables E.1-33 through E.1-36** and **Appendix E-2, Tables E.2-33 through E.2-36**). Provisional toxicity criteria (i.e., PPRTVs) present a source of uncertainty, since USEPA has evaluated the compound, but consensus has not been established on the toxicity criteria. PPRTVs or other provisional values were used for 1,1-DCA; 1,2-DCA; 2,6-DNT; TCDD TE; aluminum; cobalt; iron; thallium; and vanadium. In particular, the provisional oral RfD for thallium (1.0E-5 mg/kg-day) is from an appendix to the Derivation Support Document dated October 2010 (USEPA, 2010c), and the uncertainty associated with this RfD is greater than usual, compared with other chemical PPRTVs. Specifically, it was stated in the supporting documentation for the PPRTVs for thallium compounds (USEPA, 2010c) that it was inappropriate to derive a provisional subchronic or chronic provisional-RfD for thallium. However, information was available that, although insufficient to support derivation of a provisional toxicity value under current guidelines, may be of limited use to risk assessors. In such cases, the Superfund Health Risk Technical Support Center summarizes available information in an appendix and develops a screening value. Users of screening toxicity values in an appendix to a PPRTV assessment should understand that there is considerably more uncertainty associated with the derivation of a supplemental screening toxicity value than for a value presented in the body of the assessment. Therefore, the elevated HQs estimated for potential exposures to thallium should be viewed as screening-level HQs only.

Provisional inhalation toxicity values were used for bis(2-ethylhexyl)phthalate; 1,1-DCA; 1,2-DCA; PCP; TCDD TE; aluminum; arsenic; cadmium; cobalt; nickel; CT; 1,2-DCA; PCE; TCE; 1,2,4-trimethylbenzene; and 1,3,5-trimethylbenzene. Toxicity values for copper (oral) and barium (inhalation) were obtained from HEAST. The HEAST document, however, has not been updated since 1997. For this assessment, use of provisional toxicity criteria was preferable to not evaluating the chemical in order to limit data gaps. However, because these toxicity criteria have not been formally accepted by USEPA, there is uncertainty with these values and, therefore, with the risks calculated using these toxicity criteria.

For some chemicals, toxicity criteria were unavailable (**Appendix E-1, Tables E.1-33 through E.1-36** and **Appendix E-2, Tables E.2-33 through E.2-36**). Calcium, magnesium, and sodium were identified at concentrations above the screening for groundwater at SWMUs 48 and 49. In particular, elevated concentrations of calcium (maximum value of 2,770 mg/L) and magnesium (maximum value of 1,720 mg/L) indicate that the water is very hard in the study area. Although there is no convincing evidence that hard water causes adverse effects in humans [World Health Organization (WHO), 2003], hardness levels above 500 mg/L are generally considered to be unacceptable. In addition to its poor aesthetic quality, groundwater at SWMUs 48 and 49 is unlikely to be used as source of drinking water in the future. Although lack of published toxicity data could result in an underestimation of risk and hazard in this HHRA, this uncertainty is likely to be balanced by the conservative nature of the verified toxicity values that were available for use.

It is noted that the *Supplemental SSL Guidance* (USEPA, 2002b) recommends that toxicity values for subchronic exposures be used to calculate the HQs for exposures by the construction worker. Although subchronic values for some chemicals are included in USEPA's database of PPRTVs, this website cannot be accessed without authorization. The overall lack of subchronic toxicity values for the COPCs at these sites contributes to the uncertainty of the cancer risk estimates and the HIs. Typically, subchronic toxicity values are ten-fold greater than chronic toxicity values. Because chronic toxicity values were used for all COPCs, the calculated risks and hazards are likely to be overestimated. For both SWMUs 48 and 49, however, risks and hazards for this pathway were below the target risk range and HI.

Lead was not included in the quantitative risk estimates since a dose-response toxicity value is not available for this chemical. Lead was selected as a COPC in groundwater at SWMUs 48 and 49. Residential exposures to lead were evaluated using the IEUBK model. Because the non-carcinogenic effects from lead are evaluated separately, these effects are not represented in the cumulative HI.

Because chromium was analyzed and reported as total chromium, there is uncertainty regarding the species of chromium that exists at SWMUs 48 and 49. The toxicity values for Cr(III) were used in this HHRA because Cr(III) is the predominant form of chromium in nature. Based on past processes at SWMUs 48 and 49, Cr(VI) would not be expected to be present at the site. In addition, Cr(VI) is more unstable in nature.

6.5.5 Risk Characterization

Minor uncertainty is associated with rounding of the risk and hazard estimates. Thus, the actual risk or hazard may be slightly greater or less than the presented values. A related issue is that rounding results in differences between summed risk and hazard values, depending on how the summing is performed. For example, the RAGS Table 7 and 8 spreadsheets in **Appendix E-1, Tables E.1-37 through E.1-58** and **Appendix E-2,Tables E.2-37 through E.2-58** present risks and hazards that are summed for exposure route, exposure point, exposure medium, and medium total. The individual chemical-specific risks and hazards are summed only for the initial exposure route in deriving the total. For the subsequent summations (exposure point, exposure medium, and medium total), each is the summation of the preceding sums. For this reason, there can also be or rounding-related differences between the "same" values presented in RAGS Table 9 and 10 spreadsheets in **Appendix E-1, Tables E.1-59 through E.1-80** and **Appendix E-2, Tables E.2-59 through E.2-80**.

6.6 HHRA Summary and Conclusions

This HHRA was performed to evaluate the potential human health effects associated with previous activities at SWMUs 48 and 49. Receptors evaluated for both areas included current/future maintenance worker, future industrial worker, future excavation worker, future adult resident, future child resident, and lifetime resident. Off-site adult and child residents were also evaluated for potential exposures to groundwater in the event that groundwater migrates offsite in the future.

6.6.1 SWMU 48 Summary

As presented in *Section 6.4*, the total cancer risk for current maintenance worker exposures to surface soil was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. The total cancer risk associated with groundwater was below the target risk range. The total HI was less than 1.

For the future maintenance worker, the total cancer risk associated with total soil was less than the target risk range. The total HI was less than 1. The total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For future industrial worker exposures to surface soil, the total cancer risk associated with surface soil (2E-06) was within the target risk range, primarily due to arsenic. The total HI was less than 1. The total cancer risk associated with exposures to total soil (3E-06) was within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. The total HI was less than 1. The total cancer risk associated with groundwater (1E-04) was equal to the upper limit of the target risk range of 1E-06 to 1E-04, primarily due to CT, 1,2-DCA, dioxins/furans, TCE, and arsenic. The total HI (2E+01) was above 1, primarily due to cobalt, iron, manganese, and thallium. When recalculated by target organ, the following organs were greater than 1: central nervous system (CNS) (2.7), blood (7.1), liver (7.6), thyroid (4.0), GI irritation (1.8), and hair (5.3). The MDC and the arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For the future excavation worker, the total cancer risk associated with total soil was below the target risk range. The total HI was less than 1. The total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For the future lifetime resident, the total cancer risks associated with total soil (1E-05) were within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. For future adult residents, the total HI for total soil was less than 1. The total cancer risk associated with groundwater (2E-03) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. For future adult resident exposures, the total HI (9E+01) was above 1, primarily due to CT, TCE, aluminum, arsenic, cobalt, iron, manganese, and thallium. When recalculated by target organ, the following target organs were greater than 1: CNS (19), blood (22), liver (27), skin (1.6), vascular system (1.5), thyroid (12.4), GI irritation (5.6), hair (16.5), kidney (2.5), heart (26.5), immunotoxicity (2.1), and thymus (26.5). The MDC and the arithmetic mean for lead in groundwater were above the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For the child resident, the total cancer risks associated with total soil (9E-06) was within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. For future child residents, the total HI (4E+00) was above 1; however, there were no individual COPCs with HIs above 1. The total cancer risk associated with groundwater (6E-04) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. For future child resident exposures, the total HI (1E+02) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, barium, cobalt, iron, manganese, nickel, thallium, and vanadium. When recalculated by target organ, the following target organs were above 1: CNS (46), blood (52), liver (57), skin (3.9), vascular system (3.7), thyroid (30), GI irritation (14), hair (39), kidney (6.2), heart (5.0), immunotoxicity (4.9), thymus (5.0), and spleen (1.0). It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. For the residential scenario, site concentrations were above the health protective criterion for lead. The margin-of-exposure evaluation for iron indicated that the iron intake was above the allowable range.

For future maintenance worker exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For future industrial worker exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater (1E-04) was above the target risk range of 1E-06 to 1E-04 primarily due to CT, 1,2-DCA, dioxins/furans, TCE, and arsenic. The total HI (2E+01) was above 1, primarily due to cobalt, iron, manganese, and thallium. When recalculated by target organ, the following organs were above 1: liver (7.6), CNS (2.6), blood (7.0), GI irritation (1.8), and hair (5.3). The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For future excavation worker exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

Off-site residents were evaluated to address potential future migration of COPCs in groundwater. The total cancer risk associated with groundwater (2E-03) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate; CT; 1,1-DCA; 1,2-DCA; PCP; dioxins/furans; TCE; and arsenic. For future adult resident exposures, the total HI (9E+01) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, cobalt, iron, manganese, and thallium. When recalculated by target organ, the following target organs were found to be above 1: liver (27), kidney (2.4), CNS (19), heart (27), immunotoxicity (2.1), thymus (27), skin (1.6), vascular system (1.5), GI irritation (5.5), thyroid (12), blood (22), and hair (16). The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For future child resident exposures to COPCs in off-site groundwater, the risk characterization results showed total cancer risk associated with groundwater (6E-04) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. The total HI (1E+02) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, barium, cobalt, iron, manganese, nickel, thallium, and vanadium. When recalculated by target organ, the following target organs were above 1: liver (56), kidney (5.9), CNS (45), heart (5.0), immunotoxicity (4.9), thymus (5.0), skin (3.7), vascular system (3.5), GI irritation (13), thyroid (29), spleen (1.), blood (51), and hair (38). It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. For the residential scenario, site concentrations were above the health protective criterion for lead. The margin-of-exposure evaluation for iron indicated that the iron intake was above the allowable range.

6.6.2 SWMU 49 Summary

As presented in *Section 6.4*, the total cancer risk for current maintenance worker exposures to surface soil was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. The total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For the future maintenance worker, the total cancer risk associated with total soil (3E-06) was within the target risk range, primarily due to Aroclor 1232. The total HI was less than 1. The total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For future industrial worker exposures to surface soil, the total cancer risk associated with surface soil (4E-06) was within the target risk range, primarily due to dioxins/furans and arsenic. The total HI was less than 1. The total cancer risk associated with exposures to total soil (1E-05) was within the target risk range, primarily due to dioxins/furans, Aroclor 1232, and arsenic. Arsenic has been determined to be within background concentrations for total soil. The total HI was less than 1. The total cancer risk associated with groundwater (1E-04) was equal to the upper limit of the target risk range of 1E-06 to 1E-04 primarily due to CT; 1,2-DCA; dioxins/furans; TCE; and arsenic. The total HI (2E+01) was above 1, primarily due to cobalt, iron, manganese, and thallium. When recalculated by target organ, the following organs were above 1: CNS (2.7), thyroid (4.0), blood (7.1), liver (7.7), GI irritation (1.8), and hair (5.3). The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For the future excavation worker, the total cancer risk associated with total soil was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. Similarly, the total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For the future lifetime resident, the total cancer risks associated with total soil (5E-05) were within the target risk range, primarily due to dioxins/furans, Aroclor 1232, and arsenic. Arsenic has been determined to be within background concentrations for total soil. For future adult residents, the total HI for total soil was less than 1. The total cancer risk associated with groundwater (2E-03) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. For future adult resident exposures, the total HI (9E+01) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, cobalt, iron, manganese, and thallium. When recalculated by target organ, the following target organs were above 1: CNS (19), skin (1.6), vascular system (1.5), thyroid (12.4), blood (22.0), liver (27.4), GI irritation (5.6), hair (16.5), kidney (2.4), heart (26.8), and thymus (26.8). The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For the future child resident, the total cancer risks associated with total soil (4E-05) was within the target risk range, primarily due to dioxin/furans, Aroclor 1232, and arsenic. Arsenic has been determined to be within background concentrations for total soil. The total HI (3E+00) was above 1; however, there were no individual COPCs with HIs above 1. The total cancer risk associated with groundwater (6E-04) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. The total HI (1E+02) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, barium, cobalt, iron, manganese, nickel, thallium, and vanadium. When recalculated by target organ, the following target organs were greater than 1: CNS (45.8), skin (3.9), vascular system (3.7), thyroid (29.0), blood (52.5), liver (57.2), GI irritation (13.5), hair (39.3), kidney (53.2), heart (5.0), thymus (5.0), and spleen (1.0). It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. For the residential scenario, site concentrations were above the health protective criterion for lead. The margin-of-exposure evaluation for iron indicated that the iron intake was above the allowable range.

For future maintenance worker exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

For future industrial worker exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater (1E-04) was above the target risk range of 1E-06 to 1E-04, primarily due to CT, 1,2-DCA, dioxins/furans, TCE, and arsenic. The total HI (2E+01) was above 1, primarily due to cobalt, iron, manganese, and thallium. When recalculated by target organ, the following organs were above 1: liver (7.6), CNS (2.6), thyroid (4.0), blood (7.0), GI irritation (1.8), and hair (5.3). The MDC and arithmetic mean of lead in groundwater were above the action level for lead in drinking water.

For future excavation worker exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

Off-site residents were evaluated to address potential future migration of COPCs in groundwater. The total cancer risk associated with groundwater (2E-03) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. For future adult resident exposures, the total HI (9E+01) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, cobalt, iron, manganese, and thallium. When recalculated by target organ, the following target organs were above 1: liver (27.2), kidney (2.4), CNS (18.9), skin (1.6), vascular system (1.5), thyroid (12.3), blood (21.9), GI irritation (5.5), heart (26.8), thymus (26.8) and hair (16.4). The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For future child resident exposures to COPCs in off-site groundwater, the total cancer risk associated with groundwater (6E-04) was above the target risk range of 1E-06 to 1E-04, due to bis(2-ethylhexyl)phthalate, CT, 1,2-DCA, PCP, dioxins/furans, TCE, and arsenic. The total HI (1E+02) was above 1, primarily due to CT, dioxins/furans, TCE, aluminum, arsenic, barium, cobalt, iron, manganese, nickel, thallium, and vanadium. When recalculated by target organ, the following target organs were above 1: liver (55.7), kidney (5.9), CNS (44.9), skin (3.7), vascular system (3.5), thyroid (28.8), blood (51.0), GI irritation (12.8), spleen (1.0), heart (5.0), thymus (5.0), and hair (38.4). It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. For the residential scenario, site concentrations were above the health protective criterion for lead.

7.0 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

A SLERA was performed at each site to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMUs 48 and/or 49. Common methods and procedures are presented in *Section 7.1*, and individual results for SWMUs 48 and 49 are presented in *Section 7.2* and *Section 7.3*, respectively.

7.1 SLERA Methods and Procedures

This section provides the rationale for the methods and procedures used during the evaluation of the data collected at SWMUs 48 and 49 and performance of the SLERAs.

SLERAs were performed to provide an estimate of current and future ecological risk associated with potential hazardous substance releases at SWMUs 48 and 49. The results of the SLERAs contribute to the overall characterization of the sites, and the scientific/management decision point (SMDP) reached from each SLERA includes one of the following:

- There is adequate information to conclude that ecological risks are negligible and therefore there is no need for further action at the site on the basis of ecological risk.
- The information is not adequate to make a decision at this point and further refinement of data is needed to augment the ecological risk screening.
- The information collected and presented indicates that a more thorough assessment is warranted.

The SLERAs were performed following the *RFAAP Final MWP* (URS, 2003), the *RFAAP Site Screening Process* (USEPA, 2001c), the *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al., 1996), and Steps 1, 2 and 3a of the *Ecological Risk Assessment Guidance for Superfund* (*ERAGS): Process for Designing and Conducting Ecological Risk Assessments* (USEPA, 1997c). Steps 1, 2 and 3a were completed as part of the SLERAs. The addition of Step 3a focuses the outcome of the SLERAs, streamlines the review process, and allows one assessment to function as the initial forum for ecological risk management decision making at the sites.

The primary objective of the SLERAs is to assess whether there is enough information to state that there is the potential for unacceptable risks to ecological receptors as a result of potential hazardous substance releases. Characterizing the ecological communities in the vicinity of SWMU 48 and SWMU 49, assessing the particular hazardous substances being released, identifying pathways for receptor exposure, and estimating the magnitude and likelihood of potential risk to identified receptors meets this objective. The SLERAs address the potential for adverse effects to vegetation, the soil invertebrate community, wildlife, endangered and threatened species, and wetlands or other sensitive habitats that may be associated with SWMUs 48 and 49.

Concentrations of chemicals were measured in surface soil, which was the only relevant environmental media at SWMUs 48 and 49. Surface water was not present and groundwater does not discharge to the surface in the immediate vicinity of SWMUs 48 or 49, so there is no potential exposure for ecological receptors to surface water, sediment, or groundwater at the sites. Groundwater that may have been collected in association with SWMUs 48 or 49 is being assessed under MWP Work Plan Addendum 009, “Horseshoe Area Groundwater Study” (IT, 2002b). Although area-wide groundwater does ultimately discharge to the New River as mentioned previously, groundwater is being assessed as a separate study.

Using available concentration data, the SLERAs were performed by following Steps 1 and 2 of USEPA (1997c). Step 1 includes a screening-level problem formulation and ecological effects evaluation, and Step 2 includes an SL preliminary exposure estimate and risk calculation. The SLERA is organized as follows: General SWMU 48 and SWMU 49 Site Characterization (*Section 7.1.1*); Methodologies for the Identification of Chemicals of Potential Ecological Concern (COPECs) and Concentration Statistics (*Section 7.1.2*); Identification of Exposure Pathways and Potential Receptors for Analysis (*Section 7.1.3*); Identification of Assessment and Measurement Endpoints (*Section 7.1.4*); Exposure Estimation (*Section 7.1.5*); Ecological Effects Assessment (*Section 7.1.6*); Risk Characterization (*Section 7.1.7*); Direct Contact Toxicity (*Section 7.1.8*); Background Metals Evaluation (*Section 7.1.9*); and General Uncertainty Analysis (*Section 7.1.10*).

7.1.1 General SWMU 48 and SWMU 49 Site Characterization

This section includes a general discussion of the Installation, vegetative communities, a species inventory, and a discussion on threatened and endangered species. SWMUs 48 and 49 are located in the south central section of the HSA.

7.1.1.1 General Installation Background

The Virginia Department of Game and Inland Fisheries (1999) conducted the most recent Installation-wide biological survey at RFAAP. Major objectives of this survey were to sample flora and fauna, identify and delineate the major habitat community types, and provide management recommendations for both community types and threatened, endangered or species of concern. Eight community types were identified at RFAAP:

- Bottomland forest.
- Calcareous forest.
- Cliffs.
- Grasslands.
- Oak forest.
- Pine plantation.
- Successional forest.
- Water.

Endangered plants or animals were not observed at SWMUs 48 and 49 during the Installation-wide biological survey of 1999. Five state-listed rare plants were observed at RFAAP during this survey: *Clematis coattails*, *Cystoptris tennesseensis*, *Hasteola suaveolens*, *Sagittaria rigida*, and *Eleocharis intermedia*. State threatened animals located at RFAAP include the invertebrate *Speyeria idalia* and the birds *Ammodramus henslowii* (Henslow's sparrow) and *Lanius ludovicianus* (loggerhead shrike).

An earlier comprehensive inventory of the mammals, birds, reptiles, aquatic invertebrates, trees, and plants found on the Installation, and of fish inhabiting the New River where it flows through the Installation, was conducted in 1976 during the RFAAP Installation Assessment

(USATHAMA, 1976). Information from that assessment was summarized in previous documents (Dames and Moore, 1992). The summarized information was updated for the RFI through personal communication with RFAAP biologists and is presented in the following paragraphs (from URS, 2003).

Many of the reptiles, mammals, and birds listed in the assessment (USATHAMA, 1976) are believed to breed on the Installation. Migratory waterfowl are found throughout the spring and winter near the New River because the Installation is on the Atlantic Flyway. Public fishing occurs in the New River where it flows through RFAAP.

The Virginia Department of Game and Inland Fisheries identified the following terrestrial flora and fauna as endangered or threatened for Pulaski and Montgomery Counties:

- Plant species - six endangered, three threatened.
- Insect species - one endangered, four threatened.
- Bird species - three endangered.
- The locally endangered mountain lion.

In addition, a fish, salamander, four additional bird species, and the river otter are identified as species of concern in the two counties in which RFAAP is located.

Tree species at RFAAP include the shortleaf pine, loblolly pine, eastern white pine, yellow poplar, and black walnut. There are 2,537 acres of managed woodland onsite (personal communication with T. Thompson, RFAAP Conservation Specialist 1995, as cited in URS, 2003).

RFAAP is located at the boundary of the central Appalachian Ridges and Valleys Ecoregion and the central Appalachian Ecoregion (Omernik, 1986). These two Ecoregions are characterized in **Table 7-1**.

Table 7-1
Ecoregions of RFAAP

Ecoregion	Land Surface Form	Potential Natural Vegetation	Land Use
Central Appalachian Ridges and Valleys	Open low hills to open low mountains	Appalachian oak in undisturbed areas	Mosaic of cropland and pasture with some woodland and forest
Central Appalachian	Open low to high hills, open mountains	Mixed mesophytic forest[1], Appalachian oak, northern hardwoods[2]	Forest and woodland mostly ungrazed

[1] maple, buckeye, beech, tuliptree, oak, linden
[2] maple, birch, beech, hemlock

Based on previous site visits and investigations, the available photographic record was compiled (**Appendix F-1, Photos F-1 through F-7**). A Shaw ecologist performed site reconnaissance activities in June 2002. Prior to the reconnaissance, relevant information was obtained, including topographic maps, township, county, or other appropriate maps. This information was used to identify the location of potential ecological units such as streams, creeks, ponds, grasslands, forest, and wetlands on or near many of the RFAAP SWMUs. Additionally, the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, which identifies the locations of threatened and endangered species at RFAAP, was reviewed. The location of known or potential contaminant sources affecting the SWMUs and the probable gradient of the pathway by which contaminants may be released to the surrounding environment were identified. The reconnaissance was used to evaluate more subtle clues of potential effects from contaminant releases.

7.1.1.2 Surface Water

There is no surface water or aquatic habitat at the sites.

7.1.1.3 Groundwater

The proximity of SWMUs 48 and 49 to the New River (approximately 700 ft northwest of the river) make it unlikely that groundwater chemicals from SWMUs 48 or 49 are migrating to the New River. There are also no other groundwater to surface water discharges in close proximity to SWMUs 48 and 49; therefore, groundwater will not have an adverse impact on aquatic life or wildlife.

7.1.1.4 Wetlands

According to the information presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during a review of site photographs, there are no designated wetlands at SWMUs 48 and 49. There are also no wetlands close enough to the sites that could potentially be impacted or receive surface water drainage from the sites.

7.1.1.5 Vegetative Communities

Vegetative communities at the site, as presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, were verified using the photographs in **Appendix F-1**. As shown in **Appendix F-1, Photos F-1 through F-7**, the area surrounding SWMU 48 is primarily maintained grass, with some trees located along the edge. As shown in site aerial photographs, SWMU 49 contains some successional forest habitat within the southeast corner of the site. However, the surface soil samples collected from this discrete area are relatively non-impacted.

These two habitat types (grass and successional forest edge) can be expected to support different wildlife species assemblages; however, given the close proximity of the habitats to each other, many species would be expected to spend some amount of time within each community type for foraging and resting activities, depending on the season.

Based on information from the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, and confirmed during a review of available site information, the following community description is presented for typical grassland communities at RFAAP.

The grassland communities at RFAAP are an aggregation of several community types that are so intermingled that delineation is impractical. Grassland may conveniently be subdivided into old field, meadow, and cultivated field. The term old field is used here to denote areas that were formerly open and subsequently abandoned, but are still open. In most cases, these areas were formerly pasture or hayfield. Trees or shrubs may be present individually or in small groups, but a canopy is lacking. At SWMUs 48 and 49, a few saplings and young trees are expected, but not large, mature trees. There is successional forest habitat just beyond the edges of the site. Old fields, in most cases, are dominated by native, warm-season species with a wide variety of other grasses, sedges, and herbs mixed in. The two dominants are little bluestem (*Schizachyrium scoparium*) and broomsedge (*Andropogon virginicus*) with others such as *Tridens flavus, Panicum oligosanthes*, *Panicum anceps*, *Eragrostis spectabilis*, *Setaria glauca*, *Sorghastrum nutans*, and *Paspalum* being frequent. Much of the old-field community is mowed (on an infrequent basis) to help keep woody plants maintained.

Meadows are areas that are mowed regularly and, in most cases, have been planted in forage grasses for haying. These are typically non-native, cool-season species such as *Festuca elatior*, *Poa pratensis, Phleum pratense*, *Agrostis gigantea*, *Bromus inermis, Dactylis glomerata*, and *Arrhenatherum elatius*. These species may also be mixed with native species characteristic of old fields.

Cultivated fields are areas that have been plowed and seeded with various cover crops. These areas have a major ruderal component that persists after abandonment. Principal weed species are *Cirsium arvense, Carduus acanthoides, Carduus nutans, Erechtites hieracifolia, Hypochaeris radicata, Verbascum thapsus, Hieracium pilosella,* and *Datura stramonium*.

Grassland communities at RFAAP comprise 4,379 acres, or about 63 percent of the 6,901-acre total [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey].

7.1.1.6 Species Inventory

As presented in the Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey, six different taxa and several species were recorded during the survey. **Table 7-2** presents the numbers of species recorded at RFAAP associated with the grassland community type.

Table 7-2
Species Inventory within RFAAP's Grassland Community Type

Taxa	Number of Species	Typical Examples
Plants	24	little bluestem, broomsedge, panic grass, orchard grass, foxtail, timothy, thistle, fireweed, hawkweed
Invertebrates	~250 in 17 taxonomic orders	millipedes, beetles, flies, springtails, seed bugs, bees, ants, moths, butterflies, dragonflies, mantis, caddisflies, isopods, pill bugs, amphipods
Reptiles and amphibians	24	salamanders, toads, frogs, turtles, snakes
Fish	12	sunfish, minnows, trout (not expected at the site)
Birds	83	robin, swift, dove, sparrow, warbler, wren, hawk
Mammals	13	red fox, white-tailed deer, shrew, meadow vole

7.1.1.7 Threatened, Rare and Endangered Species Information

Threatened, rare, or endangered species found within the grassland community type at RFAAP include those presented in **Table 7-3** [Virginia Department of Game and Inland Fisheries (1999) Installation-Wide Biological Survey]. Given the grassland community type at the sites, it is possible these species could also occur at the sites; however, as mentioned in *Section 7.1.1.1*, no threatened, rare, or endangered species have been documented at SWMUs 48 or 49.

Table 7-3
Threatened, Rare, and Endangered Species in RFAAP's Grassland Community

Common Name	Scientific Name	Federal Status	State Status
Midland sedge	*Carex mescochorea*	not available	Watchlist
Shaggy false gromwell	*Onosmodium hispidissimum*	not available	Watchlist
Regal fritillary butterfly	*Speyeria idalia*	not available	State threatened
Henslow's sparrow	*Ammodramus henslowii*	not available	State threatened
Loggerhead shrike	*Lanius ludovicianus*	not available	State threatened

Although a unique community type (calcareous fen) exists within the RFAAP grassland community type, it is not found at or near SWMUs 48 or 49.

7.1.2 Methodologies for the Identification of COPECs and Concentration Statistics

Using the chemical results from environmental media samples collected at SWMUs 48 and 49, a subset of the chemicals detected having data of good quality and that were not a result of non-site sources are identified. The COPEC selection process is described in more detail in the following subsections; however, screening results are presented with the write-up for each site (*Sections 7.2.2 and 7.2.2*). A discussion of non-detected constituent concentrations compared with ecotoxicity screening values is presented in the Uncertainty Analysis sections for each site.

Lists of samples are presented in **Tables 7-5 and 7-12** for SWMUs 48 and 49, respectively. A general discussion of comparing non-detected constituent concentrations with ecotoxicity screening values is presented in the general Uncertainty Analysis section (*Section 7.1.10*).

7.1.2.1 Data Organization

The data for each chemical have been sorted by medium. To assess potential ecological impacts, soil data from 0-2 ft bgs have been considered. The 0- to 2-ft depth interval was selected for three primary reasons: 1) to maintain consistency with other RFAAP ecological risk assessment documents that used 0-2 ft, or a similar depth interval (e.g., *Ecological Risk Assessment Approach*, IT, 1998; *Screening Ecological Risk Assessment*, IT, 1999); 2) to address the most important ecological soil depth exposure interval, as soil depths below 2 ft would be infrequently contacted; and 3) to focus on the soil depth interval expected to have the highest COPEC concentrations, as discharges at SWMUs 48 and 49 were primarily surficial, although some deeper soils were found to be impacted at SWMU 48 *(Section 7.2.1*). Although some burrowing wildlife (e.g., the red fox) may actually burrow to depths greater than 2 ft, their prey items would be primarily associated with surface soil, and incidental contact by the fox with deeper soil is expected to be insignificant compared to exposures associated with soil in the 0- to 2-ft depth range.

Chemicals that were not detected at least once in a medium are not included in the risk assessment, although non-detect constituents are discussed in the Uncertainty Analysis section for each site (*Sections 7 2.6 and 7.3.6*).

The analytical data may have qualifiers from the analytical laboratory QC or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings from USEPA (1989a) are discussed, along with other data issues in **Appendix A-2**, **QA Analysis**. Besides taking into account the ecological depth of interest, the methodology for data summary was identical for the SLERA and the HHRA.

7.1.2.2 Descriptive Statistical Calculations

Because of the uncertainty associated with characterizing contamination in environmental media, the 95% UCL of the mean has been estimated for chemicals selected as COPECs. The calculation of EPCs follows the same procedure used for the HHRA (*Section 6.2.3*).

7.1.2.3 Frequency of Detection

Chemicals that are detected infrequently may be artifacts in the data that may not reflect site-related activity or disposal practices. These chemicals, however, have been included in the risk evaluation and a low FOD was not used to deselect COPECs.

7.1.2.4 Natural Site Constituents (Essential Nutrients)

As a conservative step, the essential nutrients calcium, magnesium, potassium, and sodium were assessed in the SLERA.

7.1.2.5 Selection of COPECs

In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium. For food chain exposure pathways, detected COPECs were selected unless they were not important bioaccumulative constituents (NIBC; USEPA, 2000c). COPEC selection for SWMU 48 and SWMU 49 are detailed in *Sections 7.2.2 and 7.2.2*, respectively.

For the SLERAs, dioxin-like compounds were treated according to procedures provided by USEPA and WHO (Van den Berg et al., 2006; USEPA, 1989b, 1994b; WHO, 1998). Dioxin-like compounds are present in the environmental media as complex mixtures. PCDDs and PCDFs consist of a family of approximately 75 and 135 congeners, respectively. To simplify the task of screening PCDDs/PCDFs for evaluation in this risk assessment, these compounds were evaluated with respect to a single member of this class of compounds. The concentration of each congener was evaluated on the basis of its concentration relative to that of 2,3,7,8-TCDD, which has been shown to be the most potent congener of the class of PCDDs/PCDFs. For the SLERA the higher of the TEFs for mammals and birds was used, as a conservative approach (Van den Berg et al., 2006; WHO, 1998). The TE procedure itself is described in the HHRA (*Section 6.1.1*).

It should be noted that USEPA recommends that aluminum should only be identified as a COPEC for those sites with soil with a pH less than 5.5 (USEPA, 2007c). The technical basis for this rationale is that soluble and toxic forms of aluminum are present in soil with soil pH values of less than 5.5. An analysis of two SWMU 48 and SWMU 49 surface soil samples revealed two samples with a pH approximately equal to or less than a pH of 5.5; 49SS01 (pH = 4.81) and 48SB08A (pH = 5.52). Therefore, aluminum was selected as a COPEC, given the Site's slightly acidic soil conditions. However, aluminum is not considered by USEPA to be an important bioaccumulator (USEPA, 2000c); therefore, aluminum was selected as a COPEC for direct contact exposure, but not for food chain exposure.

7.1.3 Identification of Exposure Pathways and Potential Receptors for Analysis

RFAAP terrestrial and aquatic wildlife may be exposed to COPECs by several pathways, including: 1) the ingestion of impacted soil, sediment, surface water, or food while foraging; 2) dermal absorption of chemicals from soil, sediment, or surface water; and, 3) inhalation of chemicals that have been wind-eroded from soil or have volatilized from soil or water. Among these potential exposure pathways, the greatest potential for exposure to chemicals is likely to result from the ingestion of chemicals in food and surface water. The incidental ingestion of impacted soil or sediment (while foraging) is a less important exposure route. The ingestion of food, soil, sediment, and surface water, however, are viable exposure pathways and were considered in the SLERAs, if relevant. As surface water or sediment samples were not collected at SWMUs 48 or 49, exposures to these media were not included.

Receptor-specific exposures via inhalation or dermal absorption were not selected for further evaluation because of a lack of appropriate exposure data, and the expectation that these pathways would be insignificant in comparison to the other exposure pathways quantified. Inhalation exposure would be expected to be minimal due to dilution of airborne COPECs in ambient air. Dermal exposure would also be expected to be minimal due to the expectation that wildlife fur or feathers would act to impede the transport the COPECs to the dermal layer.

The appropriate assessment receptors have been selected for evaluation in the SLERAs. In order to narrow the exposure characterization portion of the SLERAs on species or components that are the most likely to be affected, the SLERAs have focused the selection process on species, groups of species, or functional groups, rather than higher organization levels such as communities or ecosystems. Site biota are organized into major functional groups. For terrestrial communities, the major groups are plants and wildlife, including terrestrial invertebrates, mammals, and birds. For aquatic and/or wetland communities, the major groups are flora and fauna, including vertebrates (waterfowl and fish), aquatic invertebrates, and semi-aquatic mammals and birds. Species presence was assessed during a literature review and during the site reconnaissance prior to identification of target receptor species.

Primary criteria for selecting appropriate assessment receptors included, but were not limited to, the following:

- The assessment receptor will have a relatively high likelihood of contacting chemicals via direct or indirect exposure.
- The assessment receptor will exhibit marked sensitivity to the COPECs given their mode of toxicity, propensity to bioaccumulate, etc.
- The assessment receptor will be a key component of ecosystem structure or function (e.g., importance in the food web, ecological relevance).

7.1.3.1 Terrestrial Receptors

Five representative receptor species that are expected or possible in the area of SWMUs 48 and 49 were selected as indicator species for the potential effects of COPECs. These indicator species represent two classes of vertebrate wildlife (mammals and birds) and a range of both body size and food habits, including herbivory, omnivory, and carnivory. Note: Potential impacts to terrestrial plants were considered by documenting the presence or absence of vegetative stress at the site as well as by comparing soil concentrations with conservative screening values. The five animal species selected include the meadow vole (*Microtus pennsylvanicus*) (small, herbivorous mammal), short-tailed shrew (*Blarina brevicauda*) (small, insectivorous mammal), American robin (*Turdus migratorius*) (small omnivorous bird), red-tailed hawk (*Buteo jamaicensis*) (large, carnivorous bird), and red fox (*Vulpes vulpes*) (medium, carnivorous mammal). Data used to model exposure for these species are summarized in **Appendix F-2, Table F-1**.

The meadow vole, shrew, and robin represent the prey base for the larger predators of the area (represented by the red-tailed hawk and the red fox). A terrestrial food web is presented on **Figure 7-1**. Many of these species have limited home ranges, particularly the meadow vole, shrew, and American robin, which make them particularly vulnerable to exposure from site constituents. Receptor profiles for these five selected species are presented in the following five sections.

Meadow Vole. The meadow vole inhabits grassy areas (upland and wetland) and obtains a significant portion of its herbivorous diet from the site. The vole resides in every area of the United States and Canada where there is good grass cover, ranges in size from about 9 to 13 cm in length, and weighs between 17 and 52 grams (USEPA, 1993). The meadow vole has a limited foraging range, increasing its potential to be exposed (directly or indirectly) to COPECs in on-site surface soil. The vole has an average home range of 0.09 acres, with summer ranges larger than winter ranges. The vole does not hibernate and is active year-round. Population densities can range up to several hundred per hectare (approximately 40 to 80 per acre) (USEPA, 1993).

Short-Tailed Shrew. The short-tailed shrew is an insectivore that feeds largely on soil invertebrates. It would be potentially exposed to COPECs through prey items and have a relatively high rate of incidental ingestion of soil while foraging on earthworms. This short-tailed shrew weighs between 15 and 29 grams (Whitaker, 1995). Total length of this shrew is 76 to 102 millimeters (Burt and Grossenheider, 1980). The range of this shrew extends from southeastern Canada and the northeastern U.S. to Nebraska, Missouri, Kentucky, and in the mountains to Alabama (Whitaker, 1995). Preferable habitat for the shrew includes forests, grasslands, marshes, and brushy areas. It will make a nest of dry leaves, grass, and hair beneath logs, stumps, rocks, or debris (Burt and Grossenheider, 1980). This mammal has a voracious appetite, and will consume earthworms, other terrestrial invertebrates, and sometimes young mice (Whitaker, 1995). Mean population densities range from 5.7, in the winter, to 28 per acre in the summer (USEPA, 1993). Their home range varies from 0.5 to 1 acre (Burt and Grossenheider, 1980) and an average value of 0.96 acres has been used in the SLERAs (**Appendix F-2, Table F-1**).

American Robin. The American robin is an omnivore that feeds on both plants (primarily fruit) and terrestrial invertebrates including earthworms. The robin occurs throughout most of the continental United States and Canada during the breeding season and winters in the southern half of the United States and Mexico and Central America. They live in a variety of habitats, including woodlands, wetlands, suburbs and parks. Robins are likely to forage throughout RFAAP and are present year-round. Most robins build nests of mud and vegetation on the ground or in the crotches of trees or shrubs. Robins forage primarily on the ground and in low vegetation by probing and gleaning. They are approximately 25 cm in size, have a body weight range of 63 to 103 grams, and an average home range of 1.2 acres (USEPA, 1993).

Red-Tailed Hawk. The red-tailed hawk is a common predator in the mixed landscapes typifying RFAAP. The wooded habitats and riverside trees within RFAAP are considered ideal foraging and nesting habitats for these raptors. This hawk is one of the most common and widespread members of the genus *Buteo* in the continental United States and Canada (Brown and Amadon, 1968). Red-tailed hawks live in a variety of habitats, such as farmlands, woodlands, mountains, and deserts, as long as there is open country interspersed with woods, bluffs, or streamside trees. They are primarily carnivorous, feeding on small rodents, as well as fish. Other prey items include amphibians, reptiles, crayfish, and other birds (Adamcik et al., 1979;

Ehrlich et al., 1988). Home range has been reported as small as 66.8 acres, with a population density of 0.16 pairs per acre (Janes, 1984), although USEPA (1993) reports an average territory size of 2,081 acres. Breeding population density is one nest per 0.009 acre or one individual per 0.004 acre. Body weight for male red-tails is 1,028.6 to 1,142.9 grams, and for females 1,371.4 to 1,600 grams (Brown and Amadon, 1968), although USEPA (1993) reports an average body weight of 1,134 grams. More northerly populations are migratory, while the more southerly are year-round residents.

Red Fox. The red fox is a carnivorous predator that occurs in a wide range of habitats typical of RFAAP. Red fox use many types of habitat, including cropland, rolling farmland, brush, pastures, hardwood stands, and coniferous forests. They are present throughout the United States and Canada, and are the most widely distributed carnivore in the world. These foxes have a length of 56 to 63 cm, with a 35- to 41-cm tail and an average weight of 4,530 grams. They do not undergo hibernation, and most often occupy abandoned burrows or dens of other species.

One fox family per 100 to 1,000 hectares (247 to 2,471 acres) is typical, and the average home range is 892 hectares (2,204 acres) (USEPA, 1993). Fecundity is higher in areas of high mortality and low population density.

A pictorial representation of potential exposure has been prepared and is presented as **Figure 7-1**. This food web pictorial clarifies the conceptual site exposure model (CSEM). The CSEM traces the contaminant pathways through both abiotic components and biotic food web components of the environment. The CSEM presents potentially complete exposure pathways.

7.1.4 Identification of Assessment and Measurement Endpoints

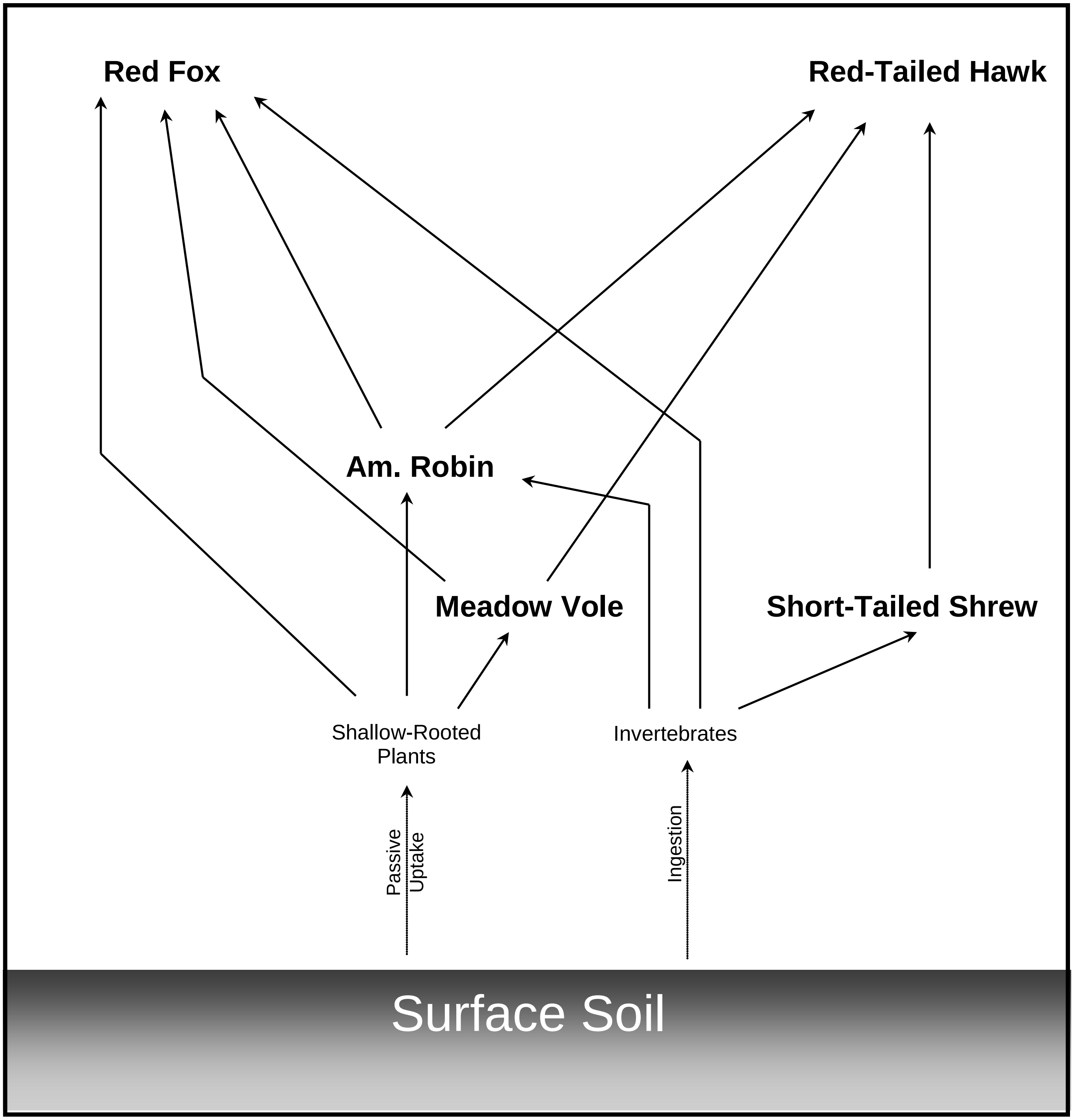
The protection of ecological resources, such as habitats and species of plants and animals, is a principal motivation for conducting the SLERAs. To assess whether the protection of these resources are met at the site, assessment and measurement endpoints have been formulated to define the specific ecological values to be protected and to define the degree to which each may be protected.

Unlike the HHRA process, which focuses on individual receptors, a SLERA focuses on populations or groups of interbreeding nonhuman, non-domesticated receptors. In the SLERA process, the risks to individuals are generally assessed if they are protected under the Endangered Species Act.

Selected assessment endpoints reflect environmental values that are protected by law, are critical resources, and/or have relevance to ecological functions that may be impaired. Both the entity and attribute are identified for each assessment endpoint (Suter, 1993).

Assessment endpoints are inferred from effects to one or more measurement endpoints. The measurement endpoint is a measurable response to a stressor that is related to the valued attribute of the chosen assessment endpoint. It serves as a surrogate attribute of the ecological entity of interest (or of a closely related ecological entity) that can be used to draw a predictive conclusion about the potential for effects to the assessment endpoint.

Figure 7-1
Simplified Terrestrial Food Web
Conceptual Site Exposure Model (CSEM)



Measurement endpoints for the SLERAs are based on toxicity values from the available literature. When possible, receptors and endpoints have been concurrently selected by identifying those that are known to be adversely affected by chemicals at the site based on published literature.

7.1.4.1 Assessment Endpoints

ERAGS (USEPA, 1997c) states: "For the screening-level ecological risk assessment, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce the habitats' ability to support plant and animal populations and communities."

The selected assessment endpoints for SWMUs 48 and 49 are stated as the protection of long-term survival and reproductive capabilities for populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. The corresponding null hypothesis (H_o) for each of the assessment endpoints is stated as: the presence of site contaminants within soil, surface water, sediment, vegetation, and prey will have no effect on the survival or reproductive capabilities of populations of herbivorous, insectivorous, and carnivorous mammals, and omnivorous, piscivorous, and carnivorous birds. In addition, assessment endpoints for the base of the food chain are stated as the protection of long-term survival and reproduction of terrestrial plants and soil invertebrates.

The food web CSEM was developed to illustrate how the selected terrestrial species are ecologically linked. For terrestrial invertebrates, small prey items, and plants, partitioning coefficients and simple empirical uptake models were employed to estimate COPEC concentrations within tissues (*Section 7.1.5*). These tissue concentrations were then used as input values for exposure to higher trophic level receptors through the dietary route of exposure.

7.1.4.2 Measurement Endpoints

Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results or community diversity indices) that can be compared statistically to detect adverse responses to a site contaminant (USEPA, 1997c).

As two of the selected receptor species (the American robin and the short-tailed shrew) feed on terrestrial invertebrates, a reduction in the abundance of these invertebrates could result in an adverse impact due to food shortages. Therefore, the direct contact toxicity of COPECs to soil invertebrates was selected as a measurement endpoint for protection of long-term survival and reproductive capabilities for populations of insectivorous mammals and omnivorous birds.

7.1.5 Exposure Estimation

This section includes a discussion of how COPEC exposures were quantified, including intake (*Section 7.1.5.1*) and bioaccumulation (*Section 7.1.5.2*).

An estimate of the nature, extent, and magnitude of potential exposure of assessment receptors to COPECs that are present at or migrating from the site was developed, considering both current and reasonably plausible future use scenarios.

Ecological routes of exposure for biota may be direct (bioconcentration) or through the food web via the consumption of contaminated organisms (bioaccumulation). Food web exposure can occur when terrestrial or aquatic fauna consume contaminated biota. Direct exposure routes include dermal contact, absorption, inhalation, and ingestion. Examples of direct exposure include animals incidentally ingesting contaminated soil or sediment; animals ingesting surface water; plants absorbing contaminants by uptake from contaminated soil or sediment; and the dermal contact of aquatic organisms with contaminated surface water or sediment. In addition, as discussed in *Section 7.1.3*, dermal contact and inhalation exposures are considered insignificant compared to other quantified routes of exposure.

Bioavailability of a chemical is an important contaminant characteristic that influences the degree of chemical-receptor interaction. The surface soil pH at SWMUs 48 and 49 ranges from about 4.8 to 5.5. For purposes of the SLERAs, bioavailability is conservatively assumed to be 100 percent.

For terrestrial and aquatic faunal receptors, calculation of exposure rates relies upon determination of an organism's exposure to COPECs found in surface soil, surface water, or sediment, and on transfer factors used for food chain exposure. Exposure rates for terrestrial and aquatic wildlife receptors in these SLERAs are based solely upon ingestion of contaminants from these media and from consumption of other organisms.

7.1.5.1 Intake

The first step in estimating exposure rates for terrestrial and aquatic wildlife involves the calculation of food ingestion and drinking water intake rates for site receptors. USEPA (1993) includes a variety of exposure information for a number of avian and mammalian species. Information regarding feeding rates, watering rates, and dietary composition are available for many species, or may be estimated using allometric equations (Nagy, 1987). Data have also been gathered on incidental ingestion of soil, and are incorporated for the receptor species. This information is summarized in **Appendix F-2**, **Table F-1**. For the SLERAs, conservative Tier 1 exposures are based on maximum dietary intake, maximum incidental soil intake, minimum body weight, 100 percent site exposure [i.e., area use factor (AUF) set equal to unity], and the use of COPEC MDCs as EPCs. Less conservative Tier 2 exposures are based on average dietary and incidental soil intake, average body weight, calculated AUF based on site area and home range of the receptor species, and COPEC EPCs set equal to 95% UCLs. These Tier 2 exposures may be considered as a portion of Step 3a of the ERAGS 8-step process.

Algorithms have been evaluated for calculating exposure for terrestrial vertebrates that account for exposure via ingestion of contaminated water, incidental ingestion of contaminated soil, ingestion of plants grown in contaminated soil, and prey items. Results for these algorithms are presented in **Appendix F, Tables F-2 through F-21**, and an example calculation is presented in **Appendix F, Table F-22**.

The basic equation for estimating dose through the dietary pathway is:

$$D_p = \sum_{k=1}^{m} (C_k \times F_k \times I_k) / W$$

where:

D_p = the potential average daily dose (mg/kg-day),
C_k = the average COPEC concentration in the k^{th} food type (mg/kg dry weight)
F_k = the fraction of the k^{th} food type that is contaminated
I_k = the ingestion rate of the k^{th} food type (kg dry weight/day)
W = the body weight of the receptor (kg wet weight).

Literature values for animal-specific sediment ingestion have been used if available. However, such values generally are not available in the literature. Where sediment ingestion rates could not be found, the animal-specific incidental soil ingestion rate is used for sediment ingestion as well, if the receptors life history profile suggests a significant aquatic component, and if sediment is a medium of concern at the site.

The estimated chemical intakes for the exposed receptors for the relevant pathway and scenario are presented in the risk characterization spreadsheets for each site referenced in *Sections 7.2.3 and 7.3.3*.

7.1.5.2 Bioaccumulation and Bioconcentration Factors

For the current SLERAs, bioaccumulation factors (BAFs) and bioconcentration factors (BCFs) for soil-to-plants, soil-to-earthworms, and soil-to-small mammals and birds are presented in **Appendix F-2**, **Tables F-23, F-24, and F-25**, respectively. BAFs and/or BCFs were not available for every COPEC, but were estimated as described in the footnotes to these tables. For each BAF/BCF pathway, both a Tier 1 and Tier 2 value is presented, as recommended in the *Site Screening Process* (USEPA, 2001c) and the *RFAAP Final MWP* (URS, 2003). The Tier 1 BAF/BCF is generally the upper-bound value found in the literature, to represent a worst-case exposure scenario, while the Tier 2 BAF/BCF represents a conservative, yet more realistic exposure value.

Soil-to-plant BAF/BCF values (**Appendix F-2**, **Table F-23**) are based on information from USEPA (2007c), Efroymson (2001), Baes et al. (1984), and International Atomic Energy Agency (1994). Tier 2 values are based on regression equations, if available, that produce a BAF/BCF value that scales in a non-linear fashion with the soil COPEC concentration. If a regression equation is not available or not recommended for a particular COPEC, a median value is used for the Tier 2 assessment (Note: the median is used for the Tier 2 because this is the reported BAF/BCF). It should be noted that as the Tier 2 regression equation predicts COPEC concentrations in plants, the actual BAF/BCF value is estimated by dividing the estimated plant COPEC concentration by the soil COPEC concentration. For organic COPEC without available BAF/BCF values, the K_{ow} regression equation from USEPA (2007c) is used, as shown as follows:

$$Log\ BAF / BCF = -0.4057 \times Log\, K_{ow} + 1.781$$

where:

$\text{Log } K_{ow}$ = log octanol-water partition coefficient (see **Appendix F-2, Table F-23**)

In order to estimate Tier 1 and Tier 2 BAF/BCF plant uptake values using the USEPA (2007c) regression equation, the log K_{ow} from USEPA (2008) EPI Suite KOW WIN program was used (as plant uptake is inversely related to K_{ow}). It should be noted that the log K_{ow} values in the EPI Suite program are estimated using Syracuse Research Corporation's atom/fragment contribution method, based on the method developed by Meylan and Howard (1995). BAF/BCF values estimated for organics using the USEPA (2007c) regression equation (and log KOWs) ranged from 0.026 for Aroclor 1260 to 2.3 for Endosulfan II (**Appendix F-2**, **Table F-23**).

Soil-to-earthworm BAF/BCF values (**Appendix F-2**, **Table F-24**) are based on information from Sample et al. (1998a), Sample et al. (1999), and USEPA (2007c). Earthworms are used as a surrogate species to represent terrestrial invertebrates including insects. Tier 2 values are based on regression equations, if available, that produce a BAF/BCF value that scales in a non-linear fashion with the soil COPEC concentration. If a regression equation is not available or not recommended for a particular COPEC, an upper-bound value is used. It should be noted that as the regression equation predicts COPEC concentrations in earthworms, the actual BAF/BCF value is estimated by dividing the earthworm COPEC concentration by the soil COPEC concentration.

Soil-to-small mammal and small bird BAF/BCF values (**Appendix F-2**, **Table F-25**) are based on information from USEPA (2007c) and Sample et al. (1998b). Tier 2 values are based on regression equations (USEPA, 2007c) or upper-bound BAF/BCF values if no regression equation is available.

For direct contact exposure for soil invertebrates to COPECs in surface soil, measured COPEC concentrations in this media were simply compared with direct contact benchmarks appropriate for the soil community.

7.1.6 Ecological Effects Characterization

This ecological effects characterization section presents the selection of literature benchmark values and the development of reference toxicity values.

7.1.6.1 Selection of Literature Benchmark Values

Appropriate sources for literature benchmark values have been consulted, such as Ecological SSL (EcoSSL) chemical-specific documents (USEPA, 2010d); Toxicological Benchmarks for Wildlife (Sample et al., 1996); Development of Toxicity Reference Values (TRVs) for Conducting Ecological Risk Assessments at Naval Facilities in California (Engineering Field Activity, West, 1998); Review of the Navy - USEPA Region IX Biological Technical Assistance Group (BTAG) TRVs for Wildlife (CH2M-Hill, 2000); and, LD50 values from databases such as the Registry of Toxic Effects Concentrations [extrapolated to chronic no-observed-adverse-effect level (NOAEL) or lowest-observed-adverse-effect level (LOAEL) values using recommended Tri-Service (Wentsel et al., 1996) uncertainty factors (UFs)].

7.1.6.2 Development of Toxicity Reference Values

TRVs were selected from available data for use in the SWMUs 48 and 49 SLERAs. These TRVs focus on the growth, survival, and reproduction of species and/or populations. Empirical data are available for the specific receptor-endpoint combinations in some instances. However, for some COPECs, data on surrogate species and/or on endpoints other than the NOAEL and LOAEL had to be used. The NOAEL is a dose of each COPEC that will produce no known adverse effects in the test species. The NOAEL was judged to be an appropriate toxicological endpoint for the Tier 1 approach since it would provide the greatest degree of protection to the receptor species; however, both NOAELs and LOAELs are used for informational purposes in the Tier. Both the NOAEL and the LOAEL were also used in the Tier 2 approach; however, the LOAEL is recommended as a point of comparison for decision-making for risk management purposes. In general, LOAELs for growth, reproduction and/or developmental endpoints are thought to be protective at the population level of biological organization. In addition, in instances where data are unavailable for a site-associated COPEC, toxicological information for surrogate chemicals had to be used. Safety factors are used to adjust for these differences and extrapolate risks to the site's receptors at the NOAEL and/or LOAEL endpoint. This process is described below and the values are presented in **Appendix F-2, Tables F-26 and F-27** for NOAEL and LOAEL TRVs, respectively.

Toxicity information pertinent to identified receptors has been gathered for those analytes identified as COPECs. Because the measurement endpoint ranges from the NOAEL to the LOAEL, preference was given to chronic studies noting concentrations at which no adverse effects were observed and ones for which the lowest concentrations associated with adverse effects were observed.

Using the relevant toxicity information, TRVs have been calculated for each of the COPECs. TRVs represent NOAELs and LOAELs with safety factors incorporated for toxicity information derived from studies other than no-effects or lowest-effects studies.

TRVs have been calculated from LD_{50} values, when required, using safety factors specified in Ford et al. (1992) and reported in Wentsel et al. (1996) and summarized in the footnotes to **Appendix F-2, Tables F-26 and F-27**. As recommended by Hull et al. (2007), allometric dose scaling using body mass was not performed for chronic TRVs because this approach is not scientifically defensible and interclass toxicity extrapolations were not performed as physiological differences between classes are too great to be addressed with the use of simplistic safety factors. Separate UFs were used to account for extrapolation to the no-effects or lowest-effects endpoints, for study duration, and for extrapolation across taxonomic groups (e.g., species, genus, family, order), as shown in **Appendix F-2, Table F-28** for the receptors used in the SLERAs. Although additional safety factors may be employed for endangered species, no endangered species were selected as representative receptors and these additional safety factors were not required.

These factors were used together to derive a final adjusted TRV, as shown in the risk characterization spreadsheets referenced in *Sections 7.2.3* and *7.3.3*. TRVs provide a reference point for the comparison of toxicological effects upon exposure to a contaminant. To complete this comparison, receptor exposures to site contaminants are calculated.

7.1.7 Risk Characterization

The risk characterization phase integrates information on exposure, exposure-effects relationships, and defined or presumed target populations. The result is a determination of the likelihood, severity, and characteristics of adverse effects to environmental stressors present at a site. Qualitative and semi-quantitative approaches have been taken to estimate the likelihood of adverse effects occurring as a result of exposure of the selected site receptors to COPECs.

For this assessment, TRVs and exposure rates have been calculated and are used to generate HQs (Wentsel et al., 1996), by dividing the receptor exposure rate for each contaminant by the calculated TRV. Environmental effects quotients (EEQs) or HQs are a means of estimating the potential for adverse effects to organisms at a contaminated site, and for assessing the potential that toxicological effects will occur among site receptors.

7.1.7.1 Terrestrial Plant Impact Assessment

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, visual observations were recorded during the site reconnaissance. The overall health of the plant community at the site was comparable to the plant communities in the surrounding areas. Plants were not quantitatively evaluated in the SLERAs as the *RFAAP Final MWP* (URS, 2003) states: “Owing to the invasive and successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects.” In addition, because of an inadequate plant toxicity database, and because of the disturbed nature of the sites (i.e., mowing on an infrequent basis to eliminate woody plants), potential risks to plants are not deemed a reason to recommend further action. However, terrestrial plant impacts are discussed further in *Sections 7.2.4 and 7.3.4*.

7.1.7.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with SWMUs 48 and 49 are estimated in the SLERAs. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure values with TRVs. The EEQs (or HQs) are compared to HQ guidelines for assessing the risk posed from contaminants. It should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly-scaled statistics, and therefore an HQ above 1, even exceedingly so, does not guarantee that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Allard et al., 2007; Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. The criterion used to decide if HQ summation is appropriate and scientifically defensible includes those chemicals that have a similar mode of toxicological action. While individual contaminants may affect distinct target organs or systems within an organism, classes of chemicals may act in similar ways, thus being additive in effect.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial receptors at SWMUs 48 and 49 are presented in risk characterization tables, referenced in each site SLERA section, for the five selected receptor species.

7.1.8 Approach for the Evaluation of Direct Contact Toxicity

To evaluate direct contact exposure, for those organisms that live within an environmental medium, COPEC media concentrations are compared with BTAG-approved direct contact screening values, and secondarily, a variety of additional appropriate direct contact benchmarks. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in soil. The results are summarized in *Sections 7.2.4 and 7.3.4*.

7.1.8.1 Soil

A two-step process was used to assess direct contact soil toxicity. First, the maximum detected soil concentration was compared with the lowest available EcoSSL (USEPA, 2010d), or if an EcoSSL was not available, with the lowest BTAG (USEPA, 1995b) soil screening value. A chemical was only retained as a COPEC if the MDC exceeded the EcoSSL, or in the absence of an EcoSSL, if the MDC exceeded the BTAG soil screening value. If no EcoSSL or BTAG value was available, the value was also carried forward for comparison to other available screening values (listed below).

In the second step, the MDCs of the chemicals carried-forward were compared with up to five individual soil screening values (in addition to the BTAG screening value, if one was available):

- Dutch intervention values, Spatial Planning and Environment Circular on Target Values and Intervention Values for Soil Remediation (Netherlands Ministry of Housing, 2000).
- NOAA Screening Quick Reference Tables (SQuiRTs), Buchman, M.F., 2008.
- Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.
- Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2010d).
- Oak Ridge National Laboratory (ORNL) (1997a, ES/ER/TM-85/R3), screening benchmarks for plants.
- ORNL (1997b, ES/ER/TM-126/R2), screening benchmarks for earthworms.

7.1.9 Background Metals Considerations

A background evaluation was conducted on the surface soil analytical results to determine if any inorganic COPECs were potentially related to naturally-occurring soil concentrations. Inorganics with MDCs less than the background UTL and shown not to be statistically different based on appropriate population statistical tests are considered background related (*HHRA Section 6.4.3*). Individual results are discussed in *Sections 7.2.5 and 7.3.5*.

7.1.10 General Uncertainty Analysis

The results of the SLERA are influenced to some degree by variability and uncertainty. In theory, investigators might reduce variability by increasing sample size of the media or species sampled. Alternatively, uncertainty within the risk analysis can be reduced by using species-specific and site-specific data (i.e., to better quantify contamination of media, vegetation, and prey through: direct field measurements, toxicity testing of site-specific media, and field studies using site-specific receptor species). Detailed media, prey, and receptor field studies are costly; thus, the preliminary analyses of risk have been conducted to limit the potential use of these resource-intensive techniques to those COPECs that continue to show a relatively high potential for ecological risk. Since assessment criteria were developed based on conservative assumptions, the result of the assessment errs on the side of conservatism. This has the effect of maximizing the likelihood of accepting a false positive (Type I error: the rejection of a true null hypothesis) and simultaneously minimizing the likelihood of accepting a true negative (Type II error: the acceptance of a false null hypothesis).

The nickel BAF/BCF for soil-to-earthworms has been withdrawn by USEPA (2010d) due to a lack of sufficient data to support an uptake factor. Rather than have a data gap, this SLERA used the nickel BAF/BCF values from Sample et al. (1998a, 1999). There is some uncertainty associated with this approach.

A number of factors contribute to the overall variability and uncertainty inherent in ecological risk assessments. Variability is due primarily to measurement error; laboratory media analyses and receptor study design are the major sources of this kind of error. Uncertainty, on the other hand, is associated primarily with deficiency or irrelevancy of effects, exposure, or habitat data to actual ecological conditions at the site. Calculating an estimated value based on a large number of assumptions is often the alternative to the accurate (but costly) method of direct field or laboratory observation, measurement, or testing.

There were numerous chemical constituents not detected in surface soil analytical samples. **Appendix F-2, Tables F-29 and F-30** evaluate the uncertainty associated with these constituents' detection limits for SWMUs 48 and 49, respectively, by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value. Ecological screening values for the comparison were compiled and presented in **Appendix F-2, Table F-31**.

Some of the non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria (detailed are presented in *Sections 7.2.6 and 7.3.6*). This finding is not unexpected, given the conservative and numerically low screening values.

The general uncertainty analysis is presented in **Table 7-4** and lists some of the major assumptions made for the SLERAs; the direction of bias caused by each assumption (i.e., if the uncertainty results in an overestimate or underestimate of risk); the likely magnitude of impact [quantitative (percent difference), or qualitative (high, medium, low, or unknown)]; if possible, a description of recommendations for minimizing the identified uncertainties if the SLERA progresses to higher level assessment phases; and the ease of implementing the recommendation (USEPA, 1997c).

The uncertainty analysis identifies and, if possible, quantifies the uncertainty in the individual preliminary scoping assessment, problem formulation, exposure and effects assessment, and risk characterization phases of the SLERAs. Based on this uncertainty analysis, the most important biases that may result in an overestimation of risk include the following:

- Assuming that COPECs are 100 percent bioavailable.
- Using some laboratory-derived or empirically-estimated partitioning and transfer factors to predict COPEC concentrations in plants, invertebrates, and/or prey species.
- Use of the HQ method to estimate risks to populations or communities.

7.2 SWMU 48 Screening Level Ecological Risk Assessment

This section presents the SLERA for SWMU 48, Oily Water Burial Area. The detailed methodology used for performance of the SLERA is presented in *Section 7.1*. This section includes a Site Characterization (*Section 7.2.1*); Summary of COPEC Selection (*Section 7.2.2*); Risk Characterization (*Section 7.2.3*); Direct Contact Assessment (*Section 7.2.4*); Background Evaluation (*Section 7.2.5*); Uncertainty Analysis (*Section 7.2.6*); and Results and Conclusions (*Section 7.2.7*).

7.2.1 Site Characterization

Aerial photographs taken in 1971 and 1986 indicate that the SWMU consists of two unlined trenches identified as the northern and southern trenches. Prior to off-post waste oil reclamation (1971), approximately 200,000 gallons of oily wastewater removed from oil/water separators throughout RFAAP was reportedly disposed of in the northern trench. An interpretation of the 1971 aerial photograph (USEPA, 1992) stated that activity was first noted in this SWMU during

Table 7-4
General Uncertainty Analysis

Component	Bias	Magnitude	Ways to Minimize Uncertainty	Additional Comments
Use of 95% UCL as source-term concentration	Overestimates Risk	Medium	Use central tendency	Easy to implement, but may not be acceptable to Agency
Use of representative receptor species for site ecological community	Underestimates Risk	Low	Select additional receptor species	Easy to implement, but unlikely to change conclusions
Use of conservative foraging factors (i.e., 100%) for some species	Overestimates Risk	Medium	Use more site-specific foraging factors, i.e., less than 100%	May be difficult to obtain site-specific foraging factors
Assumption that COPECs are 100% bioavailable	Overestimates Risk	Medium to High	Obtain medium- and COPEC-specific bioavailability factors	Would be very difficult and costly to obtain these bioavailability factors
Discounting of dermal and inhalation exposure routes	Underestimates Risk	Low	Include dermal and inhalation routes of exposure	Would be difficult to quantify these routes of exposure
Use of partitioning and transfer factors to estimate COPEC concentrations in plants, invertebrates, and prey items	Overestimates Risk	Medium to High	Measure COPEC concentrations in site plants, invertebrates, and/or other prey species	Would be costly to implement, but could significantly reduce EEQs
Use of safety factors to convert LOAEL and LD_{50} toxicity data to NOAELs	Overestimates Risk	Medium	Obtain COPEC-specific NOAEL data	Would be costly to implement, unless data available in the literature
Use of UF of 8 to extrapolate TRVs between most species within the same class	Overestimates Risk	Medium	1) Assume TRVs similar for species in the same genus, family, or order; or 2) obtain species-specific NOAEL data	1) May not be accepted by Agency 2) Would be very difficult to obtain species-specific NOAEL data
Use of surrogate constituents to estimate toxicity for those COPECs without available toxicity data	Overestimates Risk	Low to Medium	Obtain COPEC-specific toxicity data	Would be very costly to obtain COPEC-specific toxicity data, unless available in the literature
Use of HQ method to estimate risks to populations or communities may be biased	Overestimates Risk	High	Perform population or community studies	Would be very costly to perform

this time period. The northern trench is defined in the aerial photograph as light colored east to west trending scars of disturbed soil that parallel the asphalt road. The site had revegetated by 1981. The southern trench was first observed in the 1986 aerial photograph, positioned at a slight angle below the northern trench. It appears that disposal activity was complete at this time, indicating that the trench was created, filled, abandoned, and revegetated between 1971 and 1986. This trench is marked by the growth of grass visibly different from the surrounding vegetation (e.g., greener and thicker) and by extensive ground subsidence. Documentation for disposal activities in this trench is currently unknown, but soil borings and the advancement of a test pit during the 1998 RFI indicate the burial of a black pellet-like material and a light colored fibrous material. Aerial photos and site location are presented on **Figures 1-1 and 2-1**.

A cleanup occurred in 2011 (including an area of 260 ft by 30 ft, to an excavation depth of between 16 and 17 ft bgs) and approximately 2,496 cubic yards of impacted soil was removed, including soil associated with historical sample 48SS2. Soil used as backfill was certified clean.

Surface soil samples associated with the site and utilized in the SLERA are listed in **Table 7-5**; note that subsurface soil samples were not used in the SLERA (see *Section 7.1.2.1* for discussion). Based on the aerial extent of soil sampling and the known site boundaries, the terrestrial habitat associated with the site is estimated to be 1 acre.

Table 7-5
SWMU 48 Sample Groupings

SURFACE SOIL	
48SB08A	48SS1
48SB09A	48SS3
48SB10A	

7.2.2 Summary of COPEC Selection

Tables 7-6 and 7-7 have been prepared for detected constituents in surface soil with the following information:

- CAS number.
- Chemical name.
- Range of detected concentrations, and associated qualifiers.
- Concentration units.
- Location of MDC.
- FOD.
- Range of detection limits.
- COPEC selection conclusion: YES or NO.
- Rationale for selection or rejection of the COPEC.

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 48
Page 1 of 2

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	91-57-6	2-Methylnaphthalene	9.60E-03	9.60E-03	mg/kg	48SB10A	1/2	1.90E-01 - 1.90E-01	Yes	DET
Surface Soil	72-54-8	4,4'-DDD	3.47E-04 J	3.89E-04 J	mg/kg	48SB08A	2/2	N/A	Yes	DET
	50-29-3	4,4'-DDT	2.31E-03	2.31E-03	mg/kg	48SB10A	1/2	7.33E-04 - 7.33E-04	Yes	DET
	120-12-7	Anthracene	7.10E-04 J	7.10E-04 J	mg/kg	48SB10A	1/5	1.90E-03 - 7.10E-01	Yes	DET
	11097-69-1	Aroclor 1254	7.69E-02 J	7.69E-02 J	mg/kg	48SB10A	1/2	3.66E-02 - 3.66E-02	Yes	DET
	56-55-3	Benzo(a)anthracene	2.90E-03	4.40E-03	mg/kg	48SB08A	2/5	4.10E-02 - 4.10E-02	Yes	DET
	50-32-8	Benzo(a)pyrene	2.40E-03	3.60E-03	mg/kg	48SB08A	2/5	1.20E+00 - 1.20E+00	Yes	DET
	205-99-2	Benzo(b)fluoranthene	4.70E-03	7.90E-03	mg/kg	48SB08A	2/5	3.10E-01 - 3.10E-01	Yes	DET
	191-24-2	Benzo(g,h,i)perylene	1.40E-03 J	2.40E-03	mg/kg	48SB08A	2/2	N/A	Yes	DET
	207-08-9	Benzo(k)fluoranthene	1.50E-03 J	2.00E-03	mg/kg	48SB08A	2/5	1.30E-01 - 1.30E-01	Yes	DET
	117-81-7	bis(2-Ethylhexyl) phthalate	1.30E+00	1.50E+00	mg/kg	48SS1	2/4	1.90E-01 - 4.80E-01	Yes	DET
	218-01-9	Chrysene	4.60E-03	8.60E-02	mg/kg	48SS1	4/5	3.20E-02 - 3.20E-02	Yes	DET
	53-70-3	Dibenz(a,h)anthracene	7.40E-04 J	7.40E-04 J	mg/kg	48SB10A	1/5	1.90E-03 - 3.10E-01	Yes	DET
	84-74-2	Di-n-butyl phthalate	8.55E+00	8.55E+00	mg/kg	48SS2	1/5	1.80E-01 - 1.30E+00	Yes	DET
	33213-65-9	Endosulfan II	4.18E-04 J	4.18E-04 J	mg/kg	48SB10A	1/2	7.33E-04 - 7.33E-04	Yes	DET
	7421-93-4	Endrin aldehyde	5.50E-04 J	5.50E-04 J	mg/kg	48SB10A	1/2	7.33E-04 - 7.33E-04	Yes	DET
	206-44-0	Fluoranthene	7.90E-03 J	1.10E-02 J	mg/kg	48SB08A	2/5	3.20E-02 - 3.20E-02	Yes	DET
	86-73-7	Fluorene	1.10E-03 J	1.10E-03 J	mg/kg	48SB10A	1/2	1.90E-03 - 1.90E-03	Yes	DET
	193-39-5	Indeno(1,2,3-cd)pyrene	1.60E-03 J	2.90E-03	mg/kg	48SB08A	2/5	2.40E+00 - 2.40E+00	Yes	DET
	72-43-5	Methoxychlor	5.67E-04 J	5.67E-04 J	mg/kg	48SB08A	1/2	7.08E-04 - 7.08E-04	Yes	DET
	91-20-3	Naphthalene	6.70E-03	6.70E-03	mg/kg	48SB10A	1/5	1.90E-01 - 7.40E-01	Yes	DET
	85-01-8	Phenanthrene	7.60E-03	2.70E-01	mg/kg	48SS1	3/5	3.20E-02 - 3.20E-02	Yes	DET
	55-63-0	Nitroglycerin	1.20E-01 J	1.50E-01 J	mg/kg	48SB10A	2/3	3.24E-01 - 3.24E-01	Yes	DET
	129-00-0	Pyrene	8.20E-03	9.50E-03	mg/kg	48SB08A	2/5	8.30E-02 - 8.30E-02	Yes	DET
	7429-90-5	Aluminum	1.09E+04	1.26E+04	mg/kg	48SB08A	2/2	N/A	Yes	DET
	7440-38-2	Arsenic	1.46E+00 L	5.96E+00	mg/kg	48SS2	4/5	2.50E+00 - 2.50E+00	Yes	DET
	7440-39-3	Barium	7.33E+01	5.72E+02	mg/kg	48SS1	5/5	N/A	Yes	DET

Table 7-6
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 48
Page 2 of 2

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	7440-41-7	Beryllium	4.40E-01 J	1.62E+00	mg/kg	48SS1	5/5	N/A	Yes	DET
	7440-70-2	Calcium	4.15E+02 J	1.59E+04 J	mg/kg	48SB10A	2/2	N/A	Yes	DET
	7440-47-3	Chromium	5.34E+00	3.95E+01	mg/kg	48SS2	5/5	N/A	Yes	DET
	7440-48-4	Cobalt	5.98E+00 J	1.03E+01 J	mg/kg	48SB08A	2/2	N/A	Yes	DET
	7440-50-8	Copper	5.39E+00	6.59E+00	mg/kg	48SB10A	2/2	N/A	Yes	DET
	7439-89-6	Iron	1.21E+04 J	1.55E+04 J	mg/kg	48SB08A	2/2	N/A	Yes	DET
	7439-92-1	Lead	4.40E+00	9.60E+01	mg/kg	48SS2	5/5	N/A	Yes	DET
	7439-95-4	Magnesium	5.87E+02 J	1.64E+03 J	mg/kg	48SB10A	2/2	N/A	Yes	DET
	7439-96-5	Manganese	2.48E+02 J	9.98E+02 J	mg/kg	48SB08A	2/2	N/A	Yes	DET
	7439-97-6	Mercury	3.00E-02 J	1.11E+00	mg/kg	48SS1	4/5	5.00E-02 - 5.00E-02	Yes	DET
	7440-02-0	Nickel	5.54E+00 J	1.86E+01	mg/kg	48SS2	5/5	N/A	Yes	DET
	7440-09-7	Potassium	6.42E+02	6.73E+02	mg/kg	48SB08A	2/2	N/A	Yes	DET
	7782-49-2	Selenium	8.59E-01	8.59E-01	mg/kg	48SS2	1/5	4.49E-01 - 1.10E+00	Yes	DET
	7440-22-4	Silver	2.39E-02	2.45E-02	mg/kg	48SS3	2/5	1.24E-02 - 1.10E+00	Yes	DET
	7440-28-0	Thallium	1.40E-01 J	1.40E-01 J	mg/kg	48SB10A	2/5	3.43E+01 - 3.43E+01	Yes	DET
	7440-62-2	Vanadium	3.08E+01 J	3.26E+01 J	mg/kg	48SB08A	2/2	N/A	Yes	DET
	7440-66-6	Zinc	2.38E+01 J	2.44E+01 J	mg/kg	48SB10A	2/2	N/A	Yes	DET

COPEC Selection Rationale Codes

Selection Reason: Detected constiuent (DET)

Notes/Definitions

N/A = Not Applicable or Not Available

COPEC = Chemical of Potential Ecological Concern

J = Estimated Value

K = Estimated Value

L = Estimated Value

mg/kg = milligrams per kilogram

Table 7-7
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 48
Page 1 of 2

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	91-57-6	2-Methylnaphthalene	9.60E-03	9.60E-03	mg/kg	48SB10A	1/2	1.90E-01 - 1.90E-01	No	NIBC
	72-54-8	4,4'-DDD	3.47E-04 J	3.89E-04 J	mg/kg	48SB08A	2/2	N/A	Yes	IBC
	50-29-3	4,4'-DDT	2.31E-03	2.31E-03	mg/kg	48SB10A	1/2	7.33E-04 - 7.33E-04	Yes	IBC
	120-12-7	Anthracene	7.10E-04 J	7.10E-04 J	mg/kg	48SB10A	1/5	1.90E-03 - 7.10E-01	Yes	IBC
	11097-69-1	Aroclor 1254	7.69E-02 J	7.69E-02 J	mg/kg	48SB10A	1/2	3.66E-02 - 3.66E-02	Yes	IBC
	56-55-3	Benzo(a)anthracene	2.90E-03	4.40E-03	mg/kg	48SB08A	2/5	4.10E-02 - 4.10E-02	Yes	IBC
	50-32-8	Benzo(a)pyrene	2.40E-03	3.60E-03	mg/kg	48SB08A	2/5	1.20E+00 - 1.20E+00	Yes	IBC
	205-99-2	Benzo(b)fluoranthene	4.70E-03	7.90E-03	mg/kg	48SB08A	2/5	3.10E-01 - 3.10E-01	Yes	IBC
	191-24-2	Benzo(g,h,i)perylene	1.40E-03 J	2.40E-03	mg/kg	48SB08A	2/2	N/A	Yes	IBC
	207-08-9	Benzo(k)fluoranthene	1.50E-03 J	2.00E-03	mg/kg	48SB08A	2/5	1.30E-01 - 1.30E-01	Yes	IBC
	117-81-7	bis(2-Ethylhexyl) phthalate	1.30E+00	1.50E+00	mg/kg	48SS1	2/4	1.90E-01 - 4.80E-01	No	NIBC
	218-01-9	Chrysene	4.60E-03	8.60E-02	mg/kg	48SS1	4/5	3.20E-02 - 3.20E-02	Yes	IBC
	53-70-3	Dibenz(a,h)anthracene	7.40E-04 J	7.40E-04 J	mg/kg	48SB10A	1/5	1.90E-03 - 3.10E-01	Yes	IBC
	84-74-2	Di-n-butyl phthalate	8.55E+00	8.55E+00	mg/kg	48SS2	1/5	1.80E-01 - 1.30E+00	No	NIBC
	33213-65-9	Endosulfan II	4.18E-04 J	4.18E-04 J	mg/kg	48SB10A	1/2	7.33E-04 - 7.33E-04	Yes	IBC
	7421-93-4	Endrin aldehyde	5.50E-04 J	5.50E-04 J	mg/kg	48SB10A	1/2	7.33E-04 - 7.33E-04	Yes	IBC
	206-44-0	Fluoranthene	7.90E-03 J	1.10E-02 J	mg/kg	48SB08A	2/5	3.20E-02 - 3.20E-02	Yes	IBC
	86-73-7	Fluorene	1.10E-03 J	1.10E-03 J	mg/kg	48SB10A	1/2	1.90E-03 - 1.90E-03	Yes	IBC
	193-39-5	Indeno(1,2,3-cd)pyrene	1.60E-03 J	2.90E-03	mg/kg	48SB08A	2/5	2.40E+00 - 2.40E+00	Yes	IBC
	72-43-5	Methoxychlor	5.67E-04 J	5.67E-04 J	mg/kg	48SB08A	1/2	7.08E-04 - 7.08E-04	No	NIBC
	91-20-3	Naphthalene	6.70E-03	6.70E-03	mg/kg	48SB10A	1/5	1.90E-01 - 7.40E-01	No	NIBC
	85-01-8	Phenanthrene	7.60E-03	2.70E-01	mg/kg	48SS1	3/5	3.20E-02 - 3.20E-02	Yes	IBC
	55-63-0	Nitroglycerin	1.20E-01 J	1.50E-01 J	mg/kg	48SB10A	2/3	3.24E-01 - 3.24E-01	No	NIBC
	129-00-0	Pyrene	8.20E-03	9.50E-03	mg/kg	48SB08A	2/5	8.30E-02 - 8.30E-02	Yes	IBC
	7429-90-5	Aluminum	1.09E+04	1.26E+04	mg/kg	48SB08A	2/2	N/A	No	NIBC
	7440-38-2	Arsenic	1.46E+00 L	5.96E+00	mg/kg	48SS2	4/5	2.50E+00 - 2.50E+00	Yes	IBC
	7440-39-3	Barium	7.33E+01	5.72E+02	mg/kg	48SS1	5/5	N/A	No	NIBC
	7440-41-7	Beryllium	4.40E-01 J	1.62E+00	mg/kg	48SS1	5/5	N/A	No	NIBC

Table 7-7
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 48
Page 2 of 2

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
	7440-70-2	Calcium	4.15E+02 J	1.59E+04 J	mg/kg	48SB10A	2/2	N/A	No	NIBC
	7440-47-3	Chromium	5.34E+00	3.95E+01	mg/kg	48SS2	5/5	N/A	Yes	IBC
	7440-48-4	Cobalt	5.98E+00 J	1.03E+01 J	mg/kg	48SB08A	2/2	N/A	No	NIBC
	7440-50-8	Copper	5.39E+00	6.59E+00	mg/kg	48SB10A	2/2	N/A	Yes	IBC
	7439-89-6	Iron	1.21E+04 J	1.55E+04 J	mg/kg	48SB08A	2/2	N/A	No	NIBC
	7439-92-1	Lead	4.40E+00	9.60E+01	mg/kg	48SS2	5/5	N/A	Yes	IBC
	7439-95-4	Magnesium	5.87E+02 J	1.64E+03 J	mg/kg	48SB10A	2/2	N/A	No	NIBC
	7439-96-5	Manganese	2.48E+02 J	9.98E+02 J	mg/kg	48SB08A	2/2	N/A	No	NIBC
	7439-97-6	Mercury	3.00E-02 J	1.11E+00	mg/kg	48SS1	4/5	5.00E-02 - 5.00E-02	Yes	IBC
	7440-02-0	Nickel	5.54E+00 J	1.86E+01	mg/kg	48SS2	5/5	N/A	Yes	IBC
	7440-09-7	Potassium	6.42E+02	6.73E+02	mg/kg	48SB08A	2/2	N/A	No	NIBC
	7782-49-2	Selenium	8.59E-01	8.59E-01	mg/kg	48SS2	1/5	4.49E-01 - 1.10E+00	Yes	IBC
	7440-22-4	Silver	2.39E-02	2.45E-02	mg/kg	48SS3	2/5	1.24E-02 - 1.10E+00	Yes	IBC
	7440-28-0	Thallium	1.40E-01 J	1.40E-01 J	mg/kg	48SB10A	2/5	3.43E+01 - 3.43E+01	No	NIBC
	7440-62-2	Vanadium	3.08E+01 J	3.26E+01 J	mg/kg	48SB08A	2/2	N/A	No	NIBC
	7440-66-6	Zinc	2.38E+01 J	2.44E+01 J	mg/kg	48SB10A	2/2	N/A	Yes	IBC

COPEC Selection Rationale Codes

Selection Reason: Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]

Deletion Reason: Not Important Bioaccumulative Compound (NIBC)

Notes/Definitions

N/A = Not Applicable or Not Available

COPEC = Chemical of Potential Ecological Concern

J = Estimated Value

K = Estimated Value

L = Estimated Value

mg/kg = milligrams per kilogram

COPECs were selected as shown in **Tables 7-6 and 7-7**. In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium (**Table 7-6**). For food chain exposure pathways, detected COPECs were selected unless they were NIBC (USEPA, 2000c) (**Table 7-7**).

Forty-three COPECs (19 inorganic and 24 organic COPECs) have been selected for surface soil direct contact exposure (**Table 7-6**).

Twenty-seven COPECs (8 inorganic and 19 organic COPECs) have been selected for surface soil for food chain exposure (**Table 7-7**). Detected chemicals that are important bioaccumulative compounds (USEPA, 2000c) are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA.

EPCs based on the statistical procedures discussed in *HHRA Section 6.2.3* are presented in **Table 7-8**. Arithmetic mean concentrations are presented for informational purposes.

7.2.3 Risk Characterization

This section presents the SLERA risk characterization results, following the detailed methods and procedures presented in *Section 7.1.7*.

7.2.3.1 Terrestrial Plant Impact Assessment

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, visual observations were recorded during the site reconnaissance, and no obvious signs of vegetative stress were noted. The overall health of the grassland/field communities at the site was comparable to those of the surrounding area. As allowed in the *RFAAP Final MWP* (URS, 2003), that states “owing to the invasive and successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects,” plants were not quantitatively evaluated in this SLERA. As there were no unique or site-specific terrestrial plant issues discovered at SWMU 48, a qualitative evaluation was deemed adequate. However, a terrestrial plant impact screening assessment is discussed in *Section 7.2.4*. It should also be noted that plants (and invertebrates) are included in the SLERA as media through which the wildlife receptors may be exposed indirectly to COPECs in the soil by means of the food chain.

7.2.3.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with SWMU 48 are estimated in this section. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure values with TRVs. The EEQs (or HQs) are compared to HQ guidelines for assessing the risk posed from contaminants. It should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly-scaled statistics, and therefore an HQ above 1, even exceedingly so, does not guarantee that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Allard et al., 2007; Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. The criterion used to decide if HQ summation is appropriate and scientifically defensible includes those chemicals that have a similar mode of toxicological action. While individual contaminants may affect distinct target organs or systems within an organism, classes of chemicals may act in similar ways, thus being additive in effect.

Table 7-8
Medium-Specific Exposure Point Concentration Summary for SWMU 48
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Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
Surface Soil	2-Methylnaphthalene	mg/kg	5.23E-02	N/A	N/A	9.60E-03	9.60E-03	mg/kg	Max	Test (7)
	4,4-DDD	mg/kg	3.68E-04	N/A	N/A	3.89E-04	3.89E-04	mg/kg	Max	Test (7)
	4,4-DDT	mg/kg	1.34E-03	N/A	N/A	2.31E-03	2.31E-03	mg/kg	Max	Test (7)
	Anthracene	mg/kg	2.13E-01	N/A	N/A	7.10E-04	7.10E-04	mg/kg	Max	Test (7)
	Benzo(a)anthracene	mg/kg	1.38E-02	N/A	N/A	4.40E-03	4.40E-03	mg/kg	Max	Test (7)
	Benzo(a)pyrene	mg/kg	3.61E-01	N/A	N/A	3.60E-03	3.60E-03	mg/kg	Max	Test (7)
	Benzo(b)fluoranthene	mg/kg	9.55E-02	N/A	N/A	7.90E-03	7.90E-03	mg/kg	Max	Test (7)
	Benzo(ghi)perylene	mg/kg	1.90E-03	N/A	N/A	2.40E-03	2.40E-03	mg/kg	Max	Test (7)
	Benzo(k)fluoranthene	mg/kg	3.97E-02	N/A	N/A	2.00E-03	2.00E-03	mg/kg	Max	Test (7)
	Bis(2-ethylhexyl) phthalate	mg/kg	7.84E-01	N/A	N/A	1.50E+00	1.50E+00	mg/kg	Max	Test (7)
	Chrysene	mg/kg	3.15E-02	N/A	N/A	8.60E-02	8.60E-02	mg/kg	Max	Test (7)
	Dibenz(ah)anthracene	mg/kg	9.33E-02	N/A	N/A	7.40E-04	7.40E-04	mg/kg	Max	Test (7)
	Di-n-butyl phthalate	mg/kg	2.01E+00	N/A	N/A	8.55E+00	8.55E+00	mg/kg	Max	Test (7)
	Endosulfan II	mg/kg	3.92E-04	N/A	N/A	4.18E-04	4.18E-04	mg/kg	Max	Test (7)
	Endrin aldehyde	mg/kg	4.58E-04	N/A	N/A	5.50E-04	5.50E-04	mg/kg	Max	Test (7)
	Fluoranthene	mg/kg	1.34E-02	N/A	N/A	1.10E-02	1.10E-02	mg/kg	Max	Test (7)
	Fluorene	mg/kg	1.03E-03	N/A	N/A	1.10E-03	1.10E-03	mg/kg	Max	Test (7)
	Indeno(1,2,3-cd)pyrene	mg/kg	7.21E-01	N/A	N/A	2.90E-03	2.90E-03	mg/kg	Max	Test (7)
	Methoxychlor	mg/kg	4.61E-04	N/A	N/A	5.67E-04	5.67E-04	mg/kg	Max	Test (7)
	Naphthalene	mg/kg	2.42E-01	N/A	N/A	6.70E-03	6.70E-03	mg/kg	Max	Test (7)
	Nitroglycerine	mg/kg	1.44E-01	N/A	N/A	1.50E-01	1.50E-01	mg/kg	Max	Test (7)
	Aroclor 1254	mg/kg	4.76E-02	N/A	N/A	7.69E-02	7.69E-02	mg/kg	Max	Test (7)
	Phenanthrene	mg/kg	6.45E-02	N/A	N/A	2.70E-01	2.70E-01	mg/kg	Max	Test (7)
	Pyrene	mg/kg	2.84E-02	N/A	N/A	9.50E-03	9.50E-03	mg/kg	Max	Test (7)
	Aluminum	mg/kg	1.18E+04	N/A	N/A	1.26E+04	1.26E+04	mg/kg	Max	Test (7)
	Arsenic	mg/kg	2.94E+00	N/A	N/A	5.96E+00	5.96E+00	mg/kg	Max	Test (7)
	Barium	mg/kg	1.88E+02	N/A	N/A	5.72E+02	5.72E+02	mg/kg	Max	Test (7)
	Beryllium	mg/kg	9.15E-01	N/A	N/A	1.62E+00	1.62E+00	mg/kg	Max	Test (7)

Table 7-8
Medium-Specific Exposure Point Concentration Summary for SWMU 48
Page 2 of 2

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
	Calcium	mg/kg	8.16E+03	N/A	N/A	1.59E+04	1.59E+04	mg/kg	Max	Test (7)
	Chromium	mg/kg	2.55E+01	N/A	N/A	3.95E+01	3.95E+01	mg/kg	Max	Test (7)
	Cobalt	mg/kg	8.14E+00	N/A	N/A	1.03E+01	1.03E+01	mg/kg	Max	Test (7)
	Copper	mg/kg	5.99E+00	N/A	N/A	6.59E+00	6.59E+00	mg/kg	Max	Test (7)
	Iron	mg/kg	1.38E+04	N/A	N/A	1.55E+04	1.55E+04	mg/kg	Max	Test (7)
	Lead	mg/kg	3.08E+01	N/A	N/A	9.60E+01	9.60E+01	mg/kg	Max	Test (7)
	Magnesium	mg/kg	1.11E+03	N/A	N/A	1.64E+03	1.64E+03	mg/kg	Max	Test (7)
	Manganese	mg/kg	6.23E+02	N/A	N/A	9.98E+02	9.98E+02	mg/kg	Max	Test (7)
	Mercury	mg/kg	3.17E-01	N/A	N/A	1.11E+00	1.11E+00	mg/kg	Max	Test (7)
	Nickel	mg/kg	9.27E+00	N/A	N/A	1.86E+01	1.86E+01	mg/kg	Max	Test (7)
	Potassium	mg/kg	6.58E+02	N/A	N/A	6.73E+02	6.73E+02	mg/kg	Max	Test (7)
	Selenium	mg/kg	4.78E-01	N/A	N/A	8.59E-01	8.59E-01	mg/kg	Max	Test (7)
	Silver	mg/kg	2.27E-01	N/A	N/A	2.45E-02	2.45E-02	mg/kg	Max	Test (7)
	Thallium	mg/kg	1.03E+01	N/A	N/A	1.40E-01	1.40E-01	mg/kg	Max	Test (7)
	Vanadium	mg/kg	3.17E+01	N/A	N/A	3.26E+01	3.26E+01	mg/kg	Max	Test (7)
	Zinc	mg/kg	2.41E+01	N/A	N/A	2.44E+01	2.44E+01	mg/kg	Max	Test (7)

Notes: N/A = Not applicable

[1] ProUCL software (version 4.0, USEPA, 2007) recommends use of Kaplan-Meier method if there are multiple detection limits.

[2] Statistical Distribution and 95% UCL as determined by ProUCL (unless otherwise noted): (G) the data were determined to follow gamma distribution; (L) the data were determined to follow lognormal distribution; (NP) the data were determined to be non-parametric; (N) the data were determined to be normally distributed.

[3] Statistic: Maximum Detected Value (Max); 95% KM Chebyshev (95% KM-Cheby); 97.5% KM Chebyshev (97.5% KM-Cheby); 99% KM Chebyshev (99% KM-Cheby); 95% KM Percentile Bootstrap (95% KM-% Btstrp); 95% KM-t (95% KM-t); 95% KM-BCA (95% KM-BCA); 95% H-UCL (95% H-UCL); 95% Chebyshev -Mean, SD- UCL (95% Cheby, Mean, SD); 97.5% Chebyshev -Mean, SD- UCL (97.5% Cheby, Mean, SD); 99% Chebyshev -Mean, SD- UCL (99% Cheby, Mean, SD); 95% UCL of Log-transformed Data (95% UCL-T) 95% Student's-t (95% Student's-t); 95% Modified-t (95% Modified-t); 95% UCL based on bootstrap statistic (95% UCL-Bst); 95% Approximate Gamma UCL (95% Approx. Gamma).

[4] Unless otherwise noted (see footnote 5), ProUCL EPC selection rationale based on, detection limit values, distribution, standard deviation, and sample size (see ProUCL output in appendix for further details):

Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): 95% UCL recommended by statistical software (e.g., ProUCL) exceeds maximum detected concentration, therefore, maximum concentration used for EPC.
Test (3): Shapiro-Wilk W test, Kolmogorov-Smirnov (K-S), and Anderson-Darling (A-D) tests, indicate data follow nonparametric distribution.
Test (4): Shapiro-Wilk W test indicates data are normally distributed.
Test (5): Shapiro-Wilk W test indicates data are log-normally distributed.
Test (6): Kolmogorov-Smirnov (K-S) and/or Anderson-Darling (A-D) tests indicate data follow gamma distribution.
Test (7): Sample size is less than or equal to 5, therefore, maximum concentration used for EPC.

[5] Infrequent detection resulted in ProUCL modeling error for this constituent, therefore distribution, average, and UCL determined using non-ProUCL bootstrap method with random numbers for NDs (see text for details).

The summation of HQs into an HI was performed in this SLERA as a conservative approach. To assess whether or not individual COPEC HQs should be segregated based on dissimilar modes of toxicological action, individual COPEC effects were evaluated. However, as risk drivers resulted in HQs ranging from less than 1 to 664 (see following paragraphs), segregation of COPECs by mode of toxicological action was not necessary.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial receptors at SWMU 48 are presented in risk characterization tables (**Appendix F-2, Tables F-2 through F-11**) for the five selected receptor species. These summed EEQs are presented in **Table 7-9** (generally rounded to two significant figures), along with the hazard driver [COPEC(s) contributing the majority of the total estimated EEQ] and the exposure pathway of concern (the pathway contributing the most to the total estimated EEQ). Note: SWMU 49 risk characterization tables are presented in **Appendix F-2, Tables F-12 through F-21**, and an example EEQ calculation is presented **Appendix F-2, Table F-22**.

Table 7-9
Wildlife EEQ Hazard Summary for Food Chain Exposure at SWMU 48

Receptor	**Tier 1[a]**		**Tier 2[b]**	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
Meadow vole	11	3	4	0.97
Hazard Driver(s)[c]:	Arsenic and Copper - plant ingestion		Arsenic - plant and soil ingestion	
Short-tailed shrew	664	84	46	6
Hazard Driver(s)[c]:	TCDD - terrestrial invertebrate ingestion		TCDD - terrestrial invertebrate ingestion	
American robin	182	55	35	7
Hazard Driver(s)[c]:	Mercury - terrestrial invertebrate ingestion		Chromium and Zinc - terrestrial invertebrate ingestion	
Red-tailed hawk	70	8	0.03	0.003
Hazard Driver(s)[c]:	4,4'-DDT - small mammal ingestion		--	
Red fox	27	4	0.003	0.0005
Hazard Driver(s)[c]:	TCDD - small mammal ingestion		--	

[a] Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.

[b] Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR less than or equal to 1.

[c] Hazard drivers are those chemicals contributing the most to the total estimated EEQ, and the primary route of exposure associated with this driver.

Notes:

EEQ = Ecological Effects Quotient.

LOAEL = Lowest Observed Adverse Effect Level

NOAEL = No Observed Adverse Effect Level

As shown in **Table 7-9**, Tier 1 total EEQs ranged from approximately 3 to 664 for the five receptor species, using TRVs based on either NOAEL or LOAEL values. The short-tailed shrew was predicted to be the most impacted, followed by the American robin, the red-tailed hawk, the red fox, and the meadow vole. The inorganic constituents arsenic, copper, and mercury; and the organic constituent TCDD were the COPECs contributing the most to the total EEQs for each of the receptors. Exposure pathways of most concern, based on the results of the Tier 1 food chain modeling, were plant, terrestrial invertebrate, and small mammal ingestion.

More realistic Tier 2 total EEQs were also elevated, especially values based on NOAEL TRVs, which ranged from 0.0005 to 46. However, Tier 2 total EEQs were much lower than Tier 1 total EEQs, and both the NOAEL and LOAEL Tier 2 total EEQs for the red-tailed hawk and red fox were below one. Tier 2 total EEQs based on LOAEL values were, 7 for the American robin 6 for the short-tailed shrew, and less than one for the meadow vole (**Table 7-9**). Chromium and zinc were identified as the main hazard drivers for the American robin based on invertebrate ingestion and TCDD was the driver for the short-tailed shrew based on earthworm ingestion.

The specific results of the Tier 2 risk estimation for the meadow vole, short-tailed shrew, and American robin are discussed below. The specific results for the red-tailed hawk and red fox are not discussed because the summed EEQs are below one.

Meadow Vole. The total EEQ for the NOAEL TRV exceeded 1 (EEQ = 4). Only arsenic (1.4) had an individual NOAEL-based EEQ that exceeded 1. The total LOAEL-based EEQ was below one. The results of the Tier 2 risk evaluation for meadow voles are presented in **Appendix F-2, Table F-3**.

Short-tailed Shrew. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (46 and 6, respectively). Six COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): TCDD (29.3), arsenic (8.7), Aroclor 1254 (1.9), zinc (1.8), lead (1.5), and mercury (1.5). Only TCDD (2.9) had an individual LOAEL-based EEQ that exceeded 1. The primary exposure pathway was the ingestion of terrestrial invertebrates. The results of the short-tailed shrew Tier 2 risk evaluation are presented in **Appendix F-2, Table F-5**.

American Robin. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (35 and 7, respectively). Six COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): zinc (10.6), 4,4-DDT (8.1), chromium (7.7), 4,4-DDD (2.5), mercury (2.2), and lead (1.7). Three COPECs had individual LOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): chromium (2.8), zinc (1.2), and mercury (1.1). The primary exposure pathway was the ingestion of earthworms. The results of the Tier 2 risk evaluation for American robins are presented in **Appendix F-2, Table F-7**.

7.2.4 Approach for the Evaluation of Direct Contact Toxicity

To evaluate direct contact exposure, for those organisms that live within an environmental medium, COPEC media concentrations are compared with BTAG-approved direct contact screening values, and secondarily, a variety of additional appropriate direct contact benchmarks. Surface soil was the only exposure medium at SWMU 48. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in soil. Detailed procedures are presented in *Section 7.1.8*, and the results are summarized in **Table 7-10**.

Table 7-10
Direct Toxicity Evaluation for Surface Soil at SWMU 48
Page 1 of 2

Chemical (1)	Detection Frequency	Maximum Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	Minimum Concentration (mg/kg)	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	NOAA SQuiRT Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded	Comment
2-Methylnaphthalene	1/2	9.60E-03	9.60E-03	9.60E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
4,4'-DDD	2/2	3.89E-04	3.89E-04	3.47E-04	2.10E-02	No								
4,4'-DDT	1/2	2.31E-03	2.31E-03	2.31E-03	2.10E-02	No								
Anthracene	1/5	7.10E-04	7.10E-04	7.10E-04	1.00E-01	No								
Aroclor 1254	1/2	7.69E-02	7.69E-02	7.69E-02	1.00E-01	No								
Benzo(a)anthracene	2/5	4.40E-03	4.40E-03	2.90E-03	1.00E-01	No								
Benzo(a)pyrene	2/5	3.60E-03	3.60E-03	2.40E-03	1.00E-01	No								
Benzo(b)fluoranthene	2/5	7.90E-03	7.90E-03	4.70E-03	1.00E-01	No								
Benzo(g,h,i)perylene	2/2	2.40E-03	2.40E-03	1.40E-03	1.00E-01	No								
Benzo(k)fluoranthene	2/5	2.00E-03	2.00E-03	1.50E-03	1.00E-01	No								
bis(2-Ethylhexyl) phthalate	2/4	1.50E+00	1.50E+00	1.30E+00	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Chrysene	4/5	8.60E-02	8.60E-02	4.60E-03	1.00E-01	No								
Dibenz(a,h)anthracene	1/5	7.40E-04	7.40E-04	7.40E-04	1.00E-01	No								
Di-n-butyl phthalate	1/5	8.55E+00	8.55E+00	8.55E+00	NVA	NVA		NVA	NVA	NVA	2.00E+02	NVA	0/1	no exceedences
Endosulfan II	1/2	4.18E-04	4.18E-04	4.18E-04	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Endrin aldehyde	1/2	5.50E-04	5.50E-04	5.50E-04	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Fluoranthene	2/5	1.10E-02	1.10E-02	7.90E-03	1.00E-01	No								
Fluorene	1/2	1.10E-03	1.10E-03	1.10E-03	1.00E-01	No								
Indeno(1,2,3-cd)pyrene	2/5	2.90E-03	2.90E-03	1.60E-03	1.00E-01	No								
Methoxychlor	1/2	5.67E-04	5.67E-04	5.67E-04	1.00E-01	No								
Naphthalene	1/5	6.70E-03	6.70E-03	6.70E-03	1.00E-01	No								
Phenanthrene	3/5	2.70E-01	2.70E-01	7.60E-03	1.00E-01	Yes	BTAG based on benzo(a)pyrene mouse study	NA	1.00E-01	NVA	NVA	NVA	1/1	BTAG based on benzo(a)pyrene study
Nitroglycerin	2/3	1.50E-01	1.50E-01	1.20E-01	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Pyrene	2/5	9.50E-03	9.50E-03	8.20E-03	1.00E-01	No								
Aluminum	2/2	1.26E+04	1.26E+04	1.09E+04	1.00E+00	Yes	pH < 5.5; Plant tox (OHMTADS)	NVA	NVA	NVA	5.00E+01	NVA	1/1	pH = 5.52
Arsenic	4/5	5.96E+00	5.96E+00	1.46E+00	1.80E+01	No								
Barium	5/5	5.72E+02	5.72E+02	7.33E+01	3.30E+02	Yes	invertebrate tox	1.60E+02	5.00E+02	3.30E+02	5.00E+02	NVA	4/4	
Beryllium	5/5	1.62E+00	1.62E+00	4.40E-01	2.10E+01	No								
Calcium	2/2	1.59E+04	1.59E+04	4.15E+02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Chromium (Cr III tox)	5/5	3.95E+01	3.95E+01	5.34E+00	2.60E+01	Yes	Bird tox (Cr III)	3.80E-01	6.40E+01	NVA	1.00E+00	4.00E-01	3/4	EcoSSL says data insufficient to derive direct contact SSL
Chromium (Cr VI tox)	5/5	3.95E+01	3.95E+01	5.34E+00	1.30E+02	No								
Cobalt	2/2	1.03E+01	1.03E+01	5.98E+00	1.30E+01	No								
Copper	2/2	6.59E+00	6.59E+00	5.39E+00	2.80E+01	No								
Iron	2/2	1.55E+04	1.55E+04	1.21E+04	5 ≤ pH ≤ 8	No								pH = 5.52
Lead	5/5	9.60E+01	9.60E+01	4.40E+00	1.10E+01	Yes	Bird tox	5.50E+00	7.00E+01	1.20E+02	5.00E+01	5.00E+02	3/5	
Magnesium	2/2	1.64E+03	1.64E+03	5.87E+02	4.40E+03	No								
Manganese	2/2	9.98E+02	9.98E+02	2.48E+02	2.20E+02	Yes	Plant tox	NVA	NVA	2.20E+02	5.00E+02	NVA	2/2	Plant tox
Mercury	4/5	1.11E+00	1.11E+00	3.00E-02	5.80E-02	Yes	No reference	3.00E-01	6.60E+00	NVA	3.00E-01	1.00E-01	3/4	No reference for BTAG
Nickel	5/5	1.86E+01	1.86E+01	5.54E+00	3.80E+01	No								
Potassium	2/2	6.73E+02	6.73E+02	6.42E+02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Selenium	1/5	8.59E-01	8.59E-01	8.59E-01	1.80E+00	No								
Silver	2/5	2.45E-02	2.45E-02	2.39E-02	5.60E+02	No								
Thallium	2/5	1.40E-01	1.40E-01	1.40E-01	1.00E-03	Yes	Plant tox (no ref)	1.00E+00	1.00E+00	NVA	1.00E+00	NVA	0/3	no exceedences

Table 7-10
Direct Toxicity Evaluation for Surface Soil at SWMU 48
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Chemical (1)	Detection Frequency	Maximum Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	Minimum Concentration (mg/kg)	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	NOAA SQuiRT Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded	Comment
Vanadium	2/2	3.26E+01	3.26E+01	3.08E+01	7.80E+00	Yes	Bird tox	4.20E+01	1.30E+02	NVA	2.00E+00	NVA	1/3	EcoSSL says data insufficient to derive direct contact SSL
Zinc	2/2	2.44E+01	2.44E+01	2.38E+01	1.00E+01	Yes	Plant tox (OHMTADS)	1.60E+01	2.00E+02	1.20E+02	5.00E+01	2.00E+02	1/5	no exceedences

All values presented in mg/kg.
NVA = No Value Available
Surface soil pH of SWMU 48 is 5.52 based on one geochemical sample (48SB08A) collected at SWMU 48.

(1) COPECs from Table 7-6.
(2) Screening toxicity values from BTAG (1995b) or EcoSSL (USEPA, 2010d). EcoSSLs given highest priority as they are more definitive.
(3) NOAA SQuiRT (Buchman, 2008).
(4) Lowest value from Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.
(5) Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2010d).
(6) Screening benchmarks for plants from ORNL (1997, ES/ER/TM-85/R3).
(7) Screening benchmarks for earthworms from ORNL (1997, ES/ER/TM-126/R2).

7.2.4.1 Soil

Based on the results of the first step, 10 COPECs were selected based on an EcoSSL or BTAG exceedance while seven additional chemicals were evaluated further because of the lack of available EcoSSL or BTAG screening values (**Table 7-10**). In the second step, the MDC of these 18 chemicals was compared with up to five individual soil screening values. The results of the second screening step are as follows:

- There were no available benchmarks available for 2-methylnaphthalene, bis(2-ethylhexyl) phthalate, endrin aldehyde, nitroglycerin, calcium, and potassium.
- The phenanthrene MDC exceeded the one available phenanthrene benchmark; however, the basis of the 0.1 mg/kg CCME benchmark was agricultural land use that is not appropriate for SWMU 48. The next highest CCME benchmark was 5 mg/kg for residential/parkland use, but this benchmark is not exceeded by the phenanthrene MDC. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 48.
- The barium MDC exceeded four of the four available barium benchmarks. Therefore, there is potential for direct contact toxicity for barium at SWMU 48. This may or may not result in the reduction of terrestrial invertebrates as a food source at SWMU 48.
- The chromium MDC exceeded three of the four available benchmarks for Cr(III); however, the EcoSSL guidance (USEPA, 2010d) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 48.
- The manganese MDC exceeded the two available benchmarks. The EcoSSL and ORNL exceedances were for plant toxicity, and as discussed in *Section 7.2.3.1*, plant toxicity is not an overriding concern for the Site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 48.
- The mercury MDC exceeded three of the four available benchmarks. Therefore, there is potential for direct contact toxicity for mercury at SWMU 48. This may or may not result in the reduction of terrestrial invertebrates as a food source at SWMU 48.
- The vanadium MDC exceeded one of the three available benchmarks; however, the EcoSSL guidance (USEPA, 2010d) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 48.
- None of the other COPECs selected in the first screening step had any benchmark exceedances.

These results suggest that direct contact toxicity for COPECs in soil may be a concern for barium and mercury. It should also be noted that toxicity to terrestrial invertebrates is assessed indirectly, as terrestrial invertebrates such as earthworms are included in the food chain models used in the assessments.

7.2.5 Background Metals Considerations

A background evaluation was conducted on the soil analytical results to determine if any inorganic COPEC drivers discussed in the previous sections were potentially related to naturally-occurring soil concentrations. From the Tier 2 LOAEL assessment, the inorganic COPEC drivers with EEQs greater than 1 for the food chain assessment were chromium, mercury, and zinc. COPEC hazard drivers for the direct contact assessment were: barium and mercury. As summarized in **Table 7-11**, all of the inorganic COPECs in SWMU 48 surface soil are attributed to background and are not considered site related, except for barium. Details of the background evaluation are presented in *HHRA Section 6.4.3*, **Tables 6-6 and 6-7** and **Appendices E-9 and E-10** (Note: Surface soil is the same for the HHRA and the SLERA, as the only soil samples collected from 0 to 2 ft bgs were from 0 to 0.5 ft).

Table 7-11
Background Comparison for Surface Soil at SWMU 48

Soil COPEC	Wilcoxon Mann Whitney Test Site or Gehan's Test > Background?	Considered to be Background?
Barium	Yes	No
Chromium	No	Yes
Mercury	No	Yes
Zinc	No	Yes

7.2.6 Uncertainty Analysis

There were 140 chemical constituents not detected in surface soil analytical samples. **Appendix F-2, Table F-29** evaluates the uncertainty associated with these constituents' detection limits by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value. Ecological screening values were compiled and presented in **Appendix F-2, Table F-31**.

Forty-eight of the non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

One inorganic (chromium) had a Tier 2 LOAEL-based EEQs that exceeded 1 when round to one significant figure (i.e., the American robin had an estimated chromium EEQ of 2.8). The organic constituent TCDD had a Tier 2 LOAEL-based EEQs that exceeded 1 when round to one significant figure (i.e., the shrew had an estimated TCDD EEQ of 2.9) Given the uncertainties associated with the SLERA process, the key parameters associated with these slightly elevated EEQs were examined in more detail in the following sections.

Chromium. For chromium, the slightly elevated American robin EEQ of 2.8 was primarily from the earthworm ingestion pathway (64 percent), with 22 percent being from soil ingestion. The LOAEL TRV of 2.78 mg/kg-day that was used was based on laboratory studies on the black duck, as cited in USEPA (2010d). This chromium LOAEL was the lowest available value from USEPA (2010d) for birds, for the critical endpoints of reproduction, growth, or survival. However, the black duck LOAEL cited in USEPA (2010d) was based on an unpublished study by Haseltine et al., and therefore, the validity of this LOAEL could not be verified. The next highest LOAEL in USEPA (2010d) was 9.91 mg/kg-day, based on a chicken study by Montozono et al. (1998). Use of this alternative LOAEL of 9.91 mg/kg-day would decrease the American robin EEQ by approximately 3.5-fold, from 2.8 to less than one 1.

A UF of 8 was used for extrapolation from a black duck chromium toxicity study to the selected wildlife receptor (the American robin) (**Appendix F-2, Table F-28**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 4 would result in the chromium EEQ of 2.8 dropping to 1 when rounded to one significant figure.

Based on this evaluation for chromium, the use of alternative factors (e.g., an alternative LOAEL TRV and/or alternative UF for TRV species extrapolation), would reduce the estimated American robin LOAEL-based EEQ to less than 1.

<u>TCDD</u>. For the slightly elevated shrew EEQ of 2.9, the primary exposure was from the invertebrate ingestion pathway (97 percent). The LOAEL of 1E-5 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-28**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 4 would result in the TCDD EEQ of 2.9 dropping below 1 when rounded to one significant figure.

7.2.7 SLERA Results and Conclusions

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 48. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-9**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-10** and discussed in *Section 7.2.4.1*.

The food chain Tier 2 NOAEL assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (arsenic; chromium; lead; mercury; zinc; Aroclor 1254; 4,4-DDT; 4,4-DDD; and TCDD) in surface soil. Based on Tier 2 LOAEL-based approach, only chromium for the robin and TCDD for the shrew had estimated EEQs greater than 1 when rounded to one significant figure. In addition, when alternative exposure and/or toxicity factors were used in the SLERA EEQ calculation for these two receptors (such as TRV extrapolation uncertainty factors of 1 and/or an alternative LOAEL TRV for chromium based on published data, not unpublished data; Section 7.2.6) estimated EEQs would be expected to drop to 1 or less. The direct contact assessment results suggest a potential reduction in wildlife food supply due to barium and mercury in surface soil; however, due to the small size of the site (1 acre), this potential reduction in food is not considered biologically significant. While some receptors have a very small home range (e.g., 0.9 acres for the meadow vole), the potential loss of soil invertebrates as a food source, due to elevated concentrations of barium and mercury over the 1 acre site, is not expected to adversely impact the local population of these small mammals, as they feed primarily on plants, not invertebrates, and individuals, in general, would be expected to alter their foraging area to adjust to local conditions that might include areas with reduced plant and/or invertebrate densities. Analysis of the site and background data indicates that all of the Tier 2 inorganic COPEC drivers (chromium, mercury, and zinc) and the direct contact constituent mercury are statistically related to naturally-occurring surface soil concentrations (*Section 7.2.5*).

Based on uncertainties of toxicity, the finding that chromium, mercury, and zinc concentrations are background related, the fact that no wildlife rare, threatened, or endangered (RTE) species have been confirmed at the SWMU study area, alternative exposure and/or toxicity factors that could be used, and the relatively small size of the SWMU (1.0 acre), additional remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

Migration of COPECs in groundwater to surface water and sediment of the New River was determined unlikely due to the distance of this receptor area from the site and therefore was not deemed to be an ecological concern.

The assessment results may serve as the foci of discussions with risk managers and regulatory agencies. It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

7.3 SWMU 49 Screening Level Ecological Risk Assessment

This section presents the SLERA for SWMU 49, Red Water Ash Burial No. 2 area. The detailed methodology used for performance of the SLERA is presented in *Section 7.1*. This section includes a Site Characterization (*Section 7.3.1*); Summary of COPEC Selection (*Section 7.3.2*); Risk Characterization (*Section 7.3.3*); Direct Contact Assessment (*Section 7.3.4*); Background Evaluation (*Section 7.3.5*); Uncertainty Analysis (*Section 7.3.6*); and Results and Conclusions (*Section 7.3.7*).

7.3.1 Site Characterization

During the 1992 VI and the 1996 RFI, a potential location for SWMU 49 was not stated, but SWMU 48 was divided into an upper and a lower disposal area. SWMU 49 was identified to be the area of SWMU 48 called the "lower disposal unit" by previous investigations. Although disposal at SWMUs 48, 49, and 50 reportedly took place in the 1970s, the units are currently inactive. SWMU 49 was identified from aerial photography as disturbed ground during active disposal in the contiguous SWMUs. SWMU 49 reportedly received 10 tons of redwater ash during its active period. There are no known release controls for the unit. No signs of release were noted during the April 1987 Site Inspection performed by the USEPA. Aerial photos and site location are presented on **Figures 1-1 and 2-1**.

Surface soil samples collected from the site and utilized in the SLERA are listed in **Table 7-12**; note that subsurface soil samples were not used in the SLERA (see *Section 7.1.2.1* for discussion). Based on the aerial extent of soil sampling and the known site boundaries, the terrestrial habitat associated with the site is estimated to be 0.1 acres.

Table 7-12
SWMU 49 Sample Groupings

SURFACE SOIL		
48SS4	49SS01	49SS04
48SS5	49SS02	49SS05
48SS6	49SS03	49SS05 (duplicate)
49SB02A		

7.3.2 Summary of COPEC Selection

Tables 7-13 and 7-14 have been prepared for detected constituents in surface soil with the following information:

- CAS number.
- Chemical name.
- Range of detected concentrations, and associated qualifiers.
- Concentration units.
- Location of MDC.
- FOD.
- Range of detection limits.
- COPEC selection conclusion: YES or NO.
- Rationale for selection or rejection of the COPEC.

COPECs were selected as shown in **Tables 7-13 and 7-14**. In general, COPECs were selected as a concern for the direct contact exposure pathway if the constituent was detected in an environmental medium (**Table 7-13**). For food chain exposure pathways, detected COPECs were selected unless they were NIBC (USEPA, 2000c) (**Table 7-14**).

Forty-eight COPECs (20 inorganic and 28 organic COPECs) have been selected for surface soil direct contact exposure (**Table 7-13**).

Thirty-one COPECs (9 inorganic and 22 organic COPECs) have been selected for surface soil for food chain exposure (**Table 7-14**). Detected chemicals that are important bioaccumulative compounds (USEPA, 2000c) are considered final food chain exposure COPECs and have been quantitatively evaluated in this SLERA.

EPCs based on the statistical procedures discussed in *HHRA Section 6.2.3* are presented in **Table 7-15**. Arithmetic mean concentrations are presented for informational purposes.

7.3.3 Risk Characterization

This section presents the SLERA risk characterization results, following the detailed methods and procedures presented in *Section 7.1.7*.

7.3.3.1 Terrestrial Plant Impact Assessment

To assess the potential impact of COPEC concentrations in surface soil on terrestrial plant species, visual observations were recorded during the site reconnaissance, and no obvious signs of vegetative stress were noted. The overall health of the grassland/field communities at the site was comparable to those of the surrounding area. As allowed in the *RFAAP Final MWP* (URS, 2003), that states “owing to the invasive and successive nature of plant communities, plants as receptors do not typically warrant a detailed examination of effects,” plants were not quantitatively evaluated in this SLERA. As there were no unique or site-specific terrestrial plant issues discovered at SWMU 49, a qualitative evaluation was deemed adequate. However, a terrestrial plant impact screening assessment is discussed in *Section 7.3.4*. It should also be

Table 7-13
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 49
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Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	N/A	2,3,7,8-TCDD TE	2.79E-06	2.62E-05	mg/kg	49SS02	4/4	N/A	Yes	DET
	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.04E-05	2.14E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	8.00E-05	1.11E-03	mg/kg	49SS02	4/4	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	7.18E-07 J	1.37E-05	mg/kg	49SS02	4/4	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	7.91E-07 J	8.47E-06	mg/kg	49SS02	4/4	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	5.88E-07 J	9.90E-06	mg/kg	49SS05	4/4	N/A	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	3.43E-07 J	6.38E-06	mg/kg	49SS02	4/4	N/A	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1.60E-06 J	3.22E-05	mg/kg	49SS05	4/4	N/A	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	7.37E-07 J	1.30E-06 J	mg/kg	49SS02	3/4	5.53E-01 - 5.53E-01	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.32E-06 J	2.22E-05	mg/kg	49SS02	4/4	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.68E-07 J	1.80E-06 J	mg/kg	49SS03	4/4	N/A	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.91E-06 J	3.72E-06 J	mg/kg	49SS02	3/4	5.53E-01 - 5.53E-01	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	4.22E-07 J	8.25E-06	mg/kg	49SS02	4/4	N/A	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	1.89E-07 J	1.02E-06 J	mg/kg	49SS05	3/3	N/A	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	9.28E-07 J	1.44E-06	mg/kg	49SS03	3/3	N/A	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.98E-07	3.18E-07 J	mg/kg	49SS03	3/4	1.98E-01 - 1.98E-01	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	4.54E-03 J	1.00E-02 J	mg/kg	49SS02	4/4	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	3.02E-05	7.36E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Heptachlorodibenzofuran	2.89E-05	7.19E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Heptachlorodibenzo-p-dioxin	1.47E-04	1.67E-03	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Hexachlorodibenzofuran	8.87E-06	2.21E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Hexachlorodibenzo-p-dioxin	1.11E-05 J	1.48E-04 J	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Pentachlorodibenzofuran	2.94E-06 J	4.63E-05 J	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Pentachlorodibenzo-p-dioxin	1.13E-06	1.46E-05 J	mg/kg	49SS05	4/4	N/A	No	TEQ
	N/A	Total Tetrachlorodibenzofuran	1.59E-06 J	1.78E-05 J	mg/kg	49SS03	4/4	N/A	No	TEQ
	N/A	Total Tetrachlorodibenzo-p-dioxin	1.20E-06 J	1.86E-05 J	mg/kg	49SS03	4/4	N/A	No	TEQ
	90-12-0	1-Methylnaphthalene	4.95E-02 J	6.54E-02 J	mg/kg	49SS02	2/4	3.00E-01 - 3.05E-01	Yes	DET
	91-57-6	2-Methylnaphthalene	6.07E-02 J	1.17E-01 J	mg/kg	49SS02	2/6	1.90E-01 - 3.05E-01	Yes	DET
	94-82-6	2,4-DB	9.21E-02	9.21E-02	mg/kg	49SS03	1/6	7.40E-02 - 1.16E+00	Yes	DET
	72-54-8	4,4'-DDD	1.01E-03	1.01E-03	mg/kg	49SS01	1/6	7.76E-04 - 1.90E-02	Yes	DET

Table 7-13
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 49
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Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	67-64-1	Acetone	5.89E-02 J	7.07E-02 J	mg/kg	49SS02	2/5	5.20E-03 - 9.20E-02	Yes	DET
	120-12-7	Anthracene	1.00E-03 J	1.00E-03 J	mg/kg	49SS01	1/9	2.00E-03 - 7.10E-01	Yes	DET
	11097-69-1	Aroclor 1254	1.09E-02 J	1.24E-01 J	mg/kg	49SS03	3/6	3.68E-02 - 3.88E-02	Yes	DET
	11096-82-5	Aroclor 1260	7.32E-02 J	1.52E-01	mg/kg	49SS02	2/6	1.90E-02 - 3.88E-02	Yes	DET
	56-55-3	Benzo(a)anthracene	6.10E-03	6.10E-03	mg/kg	49SS01	1/9	2.00E-03 - 6.10E-02	Yes	DET
	50-32-8	Benzo(a)pyrene	4.90E-03	4.90E-03	mg/kg	49SS01	1/9	2.00E-03 - 1.20E+00	Yes	DET
	205-99-2	Benzo(b)fluoranthene	9.90E-03	2.11E-02 J	mg/kg	49SS03	2/9	2.00E-03 - 3.10E-01	Yes	DET
	191-24-2	Benzo(g,h,i)perylene	2.90E-03	2.90E-03	mg/kg	49SS01	1/6	2.00E-03 - 6.10E-02	Yes	DET
	207-08-9	Benzo(k)fluoranthene	4.20E-03	4.20E-03	mg/kg	49SS01	1/9	2.00E-03 - 1.30E-01	Yes	DET
	117-81-7	bis(2-Ethylhexyl) phthalate	1.20E+00	1.20E+00	mg/kg	48SS6	1/9	1.90E-01 - 4.80E-01	Yes	DET
	218-01-9	Chrysene	1.10E-03 J	7.90E-02	mg/kg	48SS4	6/9	3.20E-02 - 6.10E-02	Yes	DET
	53-70-3	Dibenz(a,h)anthracene	2.30E-03	2.30E-03	mg/kg	49SS01	1/9	2.00E-03 - 3.10E-01	Yes	DET
	60-57-1	Dieldrin	9.45E-03 K	9.45E-03 K	mg/kg	49SB02A	1/6	7.38E-04 - 9.65E-03	Yes	DET
	84-74-2	Di-n-butyl phthalate	1.23E-01 J	1.28E-01 J	mg/kg	49SS03	2/9	1.90E-01 - 1.30E+00	Yes	DET
	33213-65-9	Endosulfan II	7.22E-03	7.22E-03	mg/kg	49SB02A	1/6	7.38E-04 - 1.90E-02	Yes	DET
	1031-07-8	Endosulfan sulfate	6.64E-03	6.64E-03	mg/kg	49SB02A	1/6	7.38E-04 - 1.90E-02	Yes	DET
	72-20-8	Endrin	7.57E-04	7.57E-04	mg/kg	49SS01	1/6	7.76E-04 - 1.90E-02	Yes	DET
	7421-93-4	Endrin aldehyde	7.23E-04 J	7.23E-04 J	mg/kg	49SS01	1/6	7.76E-04 - 1.90E-02	Yes	DET
	206-44-0	Fluoranthene	1.30E-03 J	1.40E-02	mg/kg	49SS01	2/9	3.20E-02 - 3.05E-01	Yes	DET
	86-73-7	Fluorene	1.50E-03 J	1.50E-03 J	mg/kg	49SS01	1/6	2.00E-03 - 3.05E-01	Yes	DET
	193-39-5	Indeno(1,2,3-cd)pyrene	3.40E-03	3.40E-03	mg/kg	49SS01	1/9	5.80E-02 - 2.40E+00	Yes	DET
	85-01-8	Phenanthrene	2.60E-03	3.10E-01	mg/kg	48SS4	6/9	3.20E-02 - 3.05E-01	Yes	DET
	129-00-0	Pyrene	1.10E-03 J	1.00E-02 J	mg/kg	49SS01	2/9	8.30E-02 - 3.05E-01	Yes	DET
	7429-90-5	Aluminum	9.22E+03	2.89E+04	mg/kg	49SB02A	6/6	N/A	Yes	DET
	7440-38-2	Arsenic	5.20E-01 L	8.20E+00	mg/kg	49SS03	8/9	2.50E+00 - 2.50E+00	Yes	DET
	7440-39-3	Barium	5.30E+01	1.19E+02	mg/kg	48SS6	9/9	N/A	Yes	DET
	7440-41-7	Beryllium	5.20E-01	7.40E-01	mg/kg	48SS6	8/9	4.27E-01 - 4.27E-01	Yes	DET
	7440-70-2	Calcium	3.21E+02 J	1.44E+03	mg/kg	49SS05	6/6	N/A	Yes	DET
	7440-47-3	Chromium	1.18E+01	3.03E+01	mg/kg	48SS5	9/9	N/A	Yes	DET
	7440-48-4	Cobalt	3.10E+00	5.75E+00 J	mg/kg	49SS01	6/6	N/A	Yes	DET
	7440-50-8	Copper	5.49E+00	1.76E+01	mg/kg	49SS02	6/6	N/A	Yes	DET
	7439-89-6	Iron	9.06E+03 J	3.26E+04 J	mg/kg	49SB02A	6/6	N/A	Yes	DET
	7439-92-1	Lead	1.34E+01 K	7.16E+01	mg/kg	49SS02	9/9	N/A	Yes	DET
	7439-95-4	Magnesium	5.12E+02 J	1.12E+03	mg/kg	49SS04	6/6	N/A	Yes	DET

Table 7-13
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Direct Contact Exposure at SWMU 49
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Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Direct Contact COPEC (Y/N)	Rationale for Selection or Deletion
	7439-96-5	Manganese	1.30E+02 J	5.70E+02 J	mg/kg	49SS01	6/6	N/A	Yes	DET
	7439-97-6	Mercury	4.80E-02 J	4.97E-01	mg/kg	48SS4	6/7	5.00E-02 - 5.00E-02	Yes	DET
	7440-02-0	Nickel	5.33E+00 J	1.07E+01 J	mg/kg	49SB02A	9/9	N/A	Yes	DET
	7440-09-7	Potassium	5.08E+02	1.12E+03	mg/kg	49SB02A	3/3	N/A	Yes	DET
	7782-49-2	Selenium	6.68E-01	9.40E+00 K	mg/kg	49SS04	5/9	4.49E-01 - 1.16E+00	Yes	DET
	7440-22-4	Silver	2.22E-02	2.62E-02	mg/kg	48SS4	2/8	1.24E-02 - 1.11E+00	Yes	DET
	7440-28-0	Thallium	1.00E-01 J	1.30E-01 J	mg/kg	49SB02A	2/9	4.80E+00 - 3.43E+01	Yes	DET
	7440-62-2	Vanadium	2.03E+01 J	6.39E+01 J	mg/kg	49SB02A	6/6	N/A	Yes	DET
	7440-66-6	Zinc	2.33E+01 J	5.65E+01	mg/kg	49SS02	6/6	N/A	Yes	DET

COPEC Selection Rationale Codes

Selection Reason: Detected constiuent (DET)

Deletion Reason: Dioxins and furans will be analyzed by the toxicity equivalent provided by the TCDD-TE (TEQ)

Notes/Definitions:

N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

Table 7-14
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern
for Surface Soil Food Chain Exposure at SWMU 49
Page 1 of 3

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
Surface Soil	N/A	2,3,7,8-TCDD TE	2.79E-06	2.62E-05	mg/kg	49SS02	4/4	N/A	Yes	IBC
	67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran	1.04E-05	2.14E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	35822-46-9	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	8.00E-05	1.11E-03	mg/kg	49SS02	4/4	N/A	No	TEQ
	55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran	7.18E-07 J	1.37E-05	mg/kg	49SS02	4/4	N/A	No	TEQ
	70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran	7.91E-07 J	8.47E-06	mg/kg	49SS02	4/4	N/A	No	TEQ
	39227-28-6	1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	5.88E-07 J	9.90E-06	mg/kg	49SS05	4/4	N/A	No	TEQ
	57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran	3.43E-07 J	6.38E-06	mg/kg	49SS02	4/4	N/A	No	TEQ
	57653-85-7	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1.60E-06 J	3.22E-05	mg/kg	49SS05	4/4	N/A	No	TEQ
	72918-21-9	1,2,3,7,8,9-Hexachlorodibenzofuran	7.37E-07 J	1.30E-06 J	mg/kg	49SS02	3/4	5.53E-01 - 5.53E-01	No	TEQ
	19408-74-3	1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1.32E-06 J	2.22E-05	mg/kg	49SS02	4/4	N/A	No	TEQ
	57117-41-6	1,2,3,7,8-Pentachlorodibenzofuran	1.68E-07 J	1.80E-06 J	mg/kg	49SS03	4/4	N/A	No	TEQ
	40321-76-4	1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1.91E-06 J	3.72E-06 J	mg/kg	49SS02	3/4	5.53E-01 - 5.53E-01	No	TEQ
	60851-34-5	2,3,4,6,7,8-Hexachlorodibenzofuran	4.22E-07 J	8.25E-06	mg/kg	49SS02	4/4	N/A	No	TEQ
	57117-31-4	2,3,4,7,8-Pentachlorodibenzofuran	1.89E-07 J	1.02E-06 J	mg/kg	49SS05	3/3	N/A	No	TEQ
	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	9.28E-07 J	1.44E-06	mg/kg	49SS03	3/3	N/A	No	TEQ
	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.98E-07	3.18E-07 J	mg/kg	49SS03	3/4	1.98E-01 - 1.98E-01	No	TEQ
	3268-87-9	Octachlorodibenzodioxin	4.54E-03 J	1.00E-02 J	mg/kg	49SS02	4/4	N/A	No	TEQ
	39001-02-0	Octachlorodibenzofuran	3.02E-05	7.36E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Heptachlorodibenzofuran	2.89E-05	7.19E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Heptachlorodibenzo-p-dioxin	1.47E-04	1.67E-03	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Hexachlorodibenzofuran	8.87E-06	2.21E-04	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Hexachlorodibenzo-p-dioxin	1.11E-05 J	1.48E-04 J	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Pentachlorodibenzofuran	2.94E-06 J	4.63E-05 J	mg/kg	49SS02	4/4	N/A	No	TEQ
	N/A	Total Pentachlorodibenzo-p-dioxin	1.13E-06	1.46E-05 J	mg/kg	49SS05	4/4	N/A	No	TEQ
	N/A	Total Tetrachlorodibenzofuran	1.59E-06 J	1.78E-05 J	mg/kg	49SS03	4/4	N/A	No	TEQ
	N/A	Total Tetrachlorodibenzo-p-dioxin	1.20E-06 J	1.86E-05 J	mg/kg	49SS03	4/4	N/A	No	TEQ
	94-82-6	2,4-DB	9.21E-02	9.21E-02	mg/kg	49SS03	1/6	7.40E-02 - 1.16E+00	No	NIBC
	90-12-0	1-Methylnaphthalene	4.95E-02 J	6.54E-02 J	mg/kg	49SS02	2/4	3.00E-01 - 3.05E-01	No	NIBC
	91-57-6	2-Methylnaphthalene	6.07E-02 J	1.17E-01 J	mg/kg	49SS02	2/6	1.90E-01 - 3.05E-01	No	NIBC
	72-54-8	4,4'-DDD	1.01E-03	1.01E-03	mg/kg	49SS01	1/6	7.76E-04 - 1.90E-02	Yes	IBC

Table 7-14
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 49

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
	67-64-1	Acetone	5.89E-02 J	7.07E-02 J	mg/kg	49SS02	2/5	5.20E-03 - 9.20E-02	No	NIBC
	120-12-7	Anthracene	1.00E-03 J	1.00E-03 J	mg/kg	49SS01	1/9	2.00E-03 - 7.10E-01	Yes	IBC
	11097-69-1	Aroclor 1254	1.09E-02 J	1.24E-01 J	mg/kg	49SS03	3/6	3.68E-02 - 3.88E-02	Yes	IBC
	11096-82-5	Aroclor 1260	7.32E-02 J	1.52E-01	mg/kg	49SS02	2/6	1.90E-02 - 3.88E-02	Yes	IBC
	56-55-3	Benzo(a)anthracene	6.10E-03	6.10E-03	mg/kg	49SS01	1/9	2.00E-03 - 6.10E-02	Yes	IBC
	50-32-8	Benzo(a)pyrene	4.90E-03	4.90E-03	mg/kg	49SS01	1/9	2.00E-03 - 1.20E+00	Yes	IBC
	205-99-2	Benzo(b)fluoranthene	9.90E-03	2.11E-02 J	mg/kg	49SS03	2/9	2.00E-03 - 3.10E-01	Yes	IBC
	191-24-2	Benzo(g,h,i)perylene	2.90E-03	2.90E-03	mg/kg	49SS01	1/6	2.00E-03 - 6.10E-02	Yes	IBC
	207-08-9	Benzo(k)fluoranthene	4.20E-03	4.20E-03	mg/kg	49SS01	1/9	2.00E-03 - 1.30E-01	Yes	IBC
	117-81-7	bis(2-Ethylhexyl) phthalate	1.20E+00	1.20E+00	mg/kg	48SS6	1/9	1.90E-01 - 4.80E-01	No	NIBC
	218-01-9	Chrysene	1.10E-03 J	7.90E-02	mg/kg	48SS4	6/9	3.20E-02 - 6.10E-02	Yes	IBC
	53-70-3	Dibenz(a,h)anthracene	2.30E-03	2.30E-03	mg/kg	49SS01	1/9	2.00E-03 - 3.10E-01	Yes	IBC
	60-57-1	Dieldrin	9.45E-03 K	9.45E-03 K	mg/kg	49SB02A	1/6	7.38E-04 - 9.65E-03	Yes	IBC
	84-74-2	Di-n-butyl phthalate	1.23E-01 J	1.28E-01 J	mg/kg	49SS03	2/9	1.90E-01 - 1.30E+00	No	NIBC
	33213-65-9	Endosulfan II	7.22E-03	7.22E-03	mg/kg	49SB02A	1/6	7.38E-04 - 1.90E-02	Yes	IBC
	1031-07-8	Endosulfan sulfate	6.64E-03	6.64E-03	mg/kg	49SB02A	1/6	7.38E-04 - 1.90E-02	Yes	IBC
	72-20-8	Endrin	7.57E-04	7.57E-04	mg/kg	49SS01	1/6	7.76E-04 - 1.90E-02	Yes	IBC
	7421-93-4	Endrin aldehyde	7.23E-04 J	7.23E-04 J	mg/kg	49SS01	1/6	7.76E-04 - 1.90E-02	Yes	IBC
	206-44-0	Fluoranthene	1.30E-03 J	1.40E-02	mg/kg	49SS01	2/9	3.20E-02 - 3.05E-01	Yes	IBC
	86-73-7	Fluorene	1.50E-03 J	1.50E-03 J	mg/kg	49SS01	1/6	2.00E-03 - 3.05E-01	Yes	IBC
	193-39-5	Indeno(1,2,3-cd)pyrene	3.40E-03	3.40E-03	mg/kg	49SS01	1/9	5.80E-02 - 2.40E+00	Yes	IBC
	85-01-8	Phenanthrene	2.60E-03	3.10E-01	mg/kg	48SS4	6/9	3.20E-02 - 3.05E-01	Yes	IBC
	129-00-0	Pyrene	1.10E-03 J	1.00E-02 J	mg/kg	49SS01	2/9	8.30E-02 - 3.05E-01	Yes	IBC
	7429-90-5	Aluminum	9.22E+03	2.89E+04	mg/kg	49SB02A	6/6	N/A	No	NIBC
	7440-38-2	Arsenic	5.20E-01 L	8.20E+00	mg/kg	49SS03	8/9	2.50E+00 - 2.50E+00	Yes	IBC
	7440-39-3	Barium	5.30E+01	1.19E+02	mg/kg	48SS6	9/9	N/A	No	NIBC
	7440-41-7	Beryllium	5.20E-01	7.40E-01	mg/kg	48SS6	8/9	4.27E-01 - 4.27E-01	No	NIBC
	7440-70-2	Calcium	3.21E+02 J	1.44E+03	mg/kg	49SS05	6/6	N/A	No	NIBC
	7440-47-3	Chromium	1.18E+01	3.03E+01	mg/kg	48SS5	9/9	N/A	Yes	IBC
	7440-48-4	Cobalt	3.10E+00	5.75E+00 J	mg/kg	49SS01	6/6	N/A	No	NIBC
	7440-50-8	Copper	5.49E+00	1.76E+01	mg/kg	49SS02	6/6	N/A	Yes	IBC
	7439-89-6	Iron	9.06E+03 J	3.26E+04 J	mg/kg	49SB02A	6/6	N/A	No	NIBC
	7439-92-1	Lead	1.34E+01 K	7.16E+01	mg/kg	49SS02	9/9	N/A	Yes	IBC
	7439-95-4	Magnesium	5.12E+02 J	1.12E+03	mg/kg	49SS04	6/6	N/A	No	NIBC
	7439-96-5	Manganese	1.30E+02 J	5.70E+02 J	mg/kg	49SS01	6/6	N/A	No	NIBC

Table 7-14
Occurrence, Distribution, and Selection of Chemicals of Potential Ecological Concern for Surface Soil Food Chain Exposure at SWMU 49
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Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Food Chain COPEC (Y/N)	Rationale for Selection or Deletion
	7439-97-6	Mercury	4.80E-02 J	4.97E-01	mg/kg	48SS4	6/7	5.00E-02 - 5.00E-02	Yes	IBC
	7440-02-0	Nickel	5.33E+00 J	1.07E+01 J	mg/kg	49SB02A	9/9	N/A	Yes	IBC
	7440-09-7	Potassium	5.08E+02	1.12E+03	mg/kg	49SB02A	3/3	N/A	No	NIBC
	7782-49-2	Selenium	6.68E-01	9.40E+00 K	mg/kg	49SS04	5/9	4.49E-01 - 1.16E+00	Yes	IBC
	7440-22-4	Silver	2.22E-02	2.62E-02	mg/kg	48SS4	2/8	1.24E-02 - 1.11E+00	Yes	IBC
	7440-28-0	Thallium	1.00E-01 J	1.30E-01 J	mg/kg	49SB02A	2/9	4.80E+00 - 3.43E+01	No	NIBC
	7440-62-2	Vanadium	2.03E+01 J	6.39E+01 J	mg/kg	49SB02A	6/6	N/A	No	NIBC
	7440-66-6	Zinc	2.33E+01 J	5.65E+01	mg/kg	49SS02	6/6	N/A	Yes	IBC

COPEC Selection Rationale Codes

Selection Reason: Important Bioaccumulative Compounds (IBC) [as defined in Table 4-2, of USEPA 823-R-00-001, February 2000]

Deletion Reason: Not Important Bioaccumulative Compound (NIBC)

Notes/Definitions

N/A = Not Applicable or Not Available
COPEC = Chemical of Potential Ecological Concern
J = Estimated Value
K = Estimated Value
L = Estimated Value
mg/kg = milligrams per kilogram

Table 7-15
Medium-Specific Exposure Point Concentration Summary for SWMU 49
Page 1 of 2

Scenario Timeframe: Current/Future
Medium: Soil
Exposure Medium: Surface Soil

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
	2,3,7,8-TCDD TE	mg/kg	1.67E-05	No	2.93E-05 (N)	2.62E-05	2.62E-05	mg/kg	Max	Test (2)
Surface Soil	1-Methylnaphthalene	mg/kg	5.75E-02	Yes	N/A	6.54E-02	6.54E-02	mg/kg	Max	Test (7)
	2-Methylnaphthalene	mg/kg	8.89E-02	Yes	1.46E-01 (NP)	1.17E-01	1.17E-01	mg/kg	Max	Test (2)
	2,4-DB [5]	mg/kg	9.21E-02	Yes	4.37E-01 (L)	9.21E-02	9.21E-02	mg/kg	Max	Test (2)
	4,4-DDD [5]	mg/kg	1.01E-03	Yes	9.39E-03 (L)	1.01E-03	1.01E-03	mg/kg	Max	Test (2)
	Acetone	mg/kg	6.48E-02	Yes	N/A	7.07E-02	7.07E-02	mg/kg	Max	Test (7)
	Anthracene [5]	mg/kg	1.00E-03	Yes	2.88E-01 (N)	1.00E-03	1.00E-03	mg/kg	Max	Test (2)
	Aroclor 1254	mg/kg	6.44E-02	Yes	8.03E-02 (N)	1.24E-01	8.03E-02	mg/kg	95% KM-t	Test (1)
	Aroclor 1260	mg/kg	1.13E-01	yes	1.52E-01 (NP)	1.52E-01	1.52E-01	mg/kg	95% KM-% Btstrp	Test (1)
	Benzo(a)anthracene [5]	mg/kg	6.10E-03	Yes	3.05E-02 (N)	6.10E-03	6.10E-03	mg/kg	Max	Test (2)
	Benzo(a)pyrene [5]	mg/kg	4.90E-03	Yes	4.00E-01 (L)	4.90E-03	4.90E-03	mg/kg	Max	Test (2)
	Benzo(b)fluoranthene	mg/kg	1.55E-02	Yes	2.16E-02 (NP)	2.11E-02	2.11E-02	mg/kg	Max	Test (2)
	Benzo(ghi)perylene [5]	mg/kg	2.90E-03	Yes	3.44E-02 (NP)	2.90E-03	2.90E-03	mg/kg	Max	Test (2)
	Benzo(k)fluoranthene [5]	mg/kg	4.20E-03	Yes	5.47E-02 (N)	4.20E-03	4.20E-03	mg/kg	Max	Test (2)
	Bis(2-ethylhexyl) phthalate [5]	mg/kg	1.20E+00	Yes	4.17E-01 (NP)	1.20E+00	4.17E-01	mg/kg	95% UCL-Bst	Test (3)
	Chrysene	mg/kg	3.28E-02	Yes	4.48E-02 (N)	7.90E-02	4.48E-02	mg/kg	95% KM-t	Test (1)
	Dibenz(ah)anthracene [5]	mg/kg	2.30E-03	Yes	1.15E-01 (L)	2.30E-03	2.30E-03	mg/kg	Max	Test (2)
	Dieldrin [5]	mg/kg	9.45E-03	Yes	6.88E-03 (N)	9.45E-03	6.88E-03	mg/kg	95% UCL-Bst	Test (3)
	Di-n-butyl phthalate	mg/kg	1.26E-01	Yes	1.28E-01 (NP)	1.28E-01	1.28E-01	mg/kg	95% KM-% Btstrp	Test (1)
	Endosulfan II [5]	mg/kg	7.22E-03	Yes	1.02E-02 (N)	7.22E-03	7.22E-03	mg/kg	Max	Test (2)
	Endosulfan sulfate [5]	mg/kg	6.64E-03	Yes	9.97E-03 (N)	6.64E-03	6.64E-03	mg/kg	Max	Test (2)
	Endrin [5]	mg/kg	7.57E-04	Yes	9.15E-03 (L)	7.57E-04	7.57E-04	mg/kg	Max	Test (2)
	Endrin aldehyde [5]	mg/kg	7.23E-04	Yes	9.17E-03 (L)	7.23E-04	7.23E-04	mg/kg	Max	Test (2)
	Fluoranthene	mg/kg	7.65E-03	Yes	4.73E-02 (NP)	1.40E-02	1.40E-02	mg/kg	Max	Test (2)
	Fluorene [5]	mg/kg	1.50E-03	Yes	1.74E-01 (NP)	1.50E-03	1.50E-03	mg/kg	Max	Test (2)
	Indeno(1,2,3-cd)pyrene [5]	mg/kg	3.40E-03	Yes	7.89E-01 (L)	3.40E-03	3.40E-03	mg/kg	Max	Test (2)
	Phenanthrene	mg/kg	1.24E-01	Yes	1.87E-01 (N)	3.10E-01	1.87E-01	mg/kg	95% KM-t	Test (1)
	Pyrene	mg/kg	5.55E-03	Yes	3.33E-02 (NP)	1.00E-02	1.00E-02	mg/kg	Max	Test (2)
	Aluminum	mg/kg	1.62E+04	No	2.28E+04 (N)	2.89E+04	2.28E+04	mg/kg	95% Student's-t	Test (4)
	Arsenic	mg/kg	3.60E+00	No	4.95E+00 (N)	8.20E+00	4.95E+00	mg/kg	95% KM-t	Test (4)
	Barium	mg/kg	7.85E+01	No	9.40E+01 (N)	1.19E+02	9.40E+01	mg/kg	95% Student's-t	Test (4)

Table 7-15
Medium-Specific Exposure Point Concentration Summary for SWMU 49
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Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean of Detects	Multiple Detection Limits? (Yes/No) [1]	95% UCL (Distribution) [2]	Maximum Concentration	Exposure Point Concentration			
							Value	Units	Statistic [3]	Rationale [4]
	Beryllium	mg/kg	6.16E-01	No	6.55E-01 (N)	7.40E-01	6.55E-01	mg/kg	95% KM-t	Test (4)
	Calcium	mg/kg	7.54E+02	No	1.09E+03 (N)	1.44E+03	1.09E+03	mg/kg	95% Student's-t	Test (4)
	Chromium	mg/kg	1.79E+01	No	2.18E+01 (N)	3.03E+01	2.18E+01	mg/kg	95% Student's-t	Test (4)
	Cobalt	mg/kg	4.25E+00	No	5.20E+00 (N)	5.75E+00	5.20E+00	mg/kg	95% Student's-t	Test (4)
	Copper	mg/kg	1.34E+01	No	1.68E+01 (N)	1.76E+01	1.68E+01	mg/kg	95% Student's-t	Test (4)
	Iron	mg/kg	1.90E+04	No	2.64E+04 (N)	3.26E+04	2.64E+04	mg/kg	95% Student's-t	Test (4)
	Lead	mg/kg	2.75E+01	No	5.65E+01 (NP)	7.16E+01	5.65E+01	mg/kg	95% Cheby, Mean, SD	Test (3)
	Magnesium	mg/kg	8.01E+02	No	1.02E+03 (N)	1.12E+03	1.02E+03	mg/kg	95% Student's-t	Test (4)
	Manganese	mg/kg	3.02E+02	No	4.32E+02 (N)	5.70E+02	4.32E+02	mg/kg	95% Student's-t	Test (4)
	Mercury	mg/kg	1.99E-01	No	3.03E-01 (N)	4.97E-01	3.03E-01	mg/kg	95% KM-t	Test (4)
	Nickel	mg/kg	7.45E+00	No	9.12E+00 (L)	1.07E+01	9.12E+00	mg/kg	95% H-UCL	Test (5)
	Potassium	mg/kg	8.96E+02	Yes	N/A	1.12E+03	1.12E+03	mg/kg	Max	Test (7)
	Selenium	mg/kg	5.43E+00	Yes	6.62E+01 (N)	9.40E+00	6.62E+00	mg/kg	95% KM-% Btstrp	Test (1)
	Silver	mg/kg	2.42E-02	Yes	2.65E-02 (NP)	2.62E-02	2.62E-02	mg/kg	Max	Test (2)
	Thallium	mg/kg	1.15E-01	Yes	1.43E-01 (NP)	1.30E-01	1.30E-01	mg/kg	Max	Test (2)
	Vanadium	mg/kg	3.80E+01	No	5.30E+01 (N)	6.39E+01	5.30E+01	mg/kg	95% Student's-t	Test (4)
	Zinc	mg/kg	4.33E+01	No	5.25E+01 (N)	5.65E+01	5.25E+01	mg/kg	95% Student's-t	Test (4)

Notes: N/A = Not applicable

[1] ProUCL software (version 4.0, USEPA, 2007a) recommends use of Kaplan-Meier method if there are multiple detection limits.

[2] Statistical Distribution and 95% UCL as determined by ProUCL (unless otherwise noted): (G) the data were determined to follow gamma distribution;
(L) the data were determined to follow lognormal distribution; (NP) the data were determined to be non-parametric; (N) the data were determined to be normally distributed.

[3] Statistic: Maximum Detected Value (Max); 95% KM Chebyshev (95% KM-Cheby); 97.5% KM Chebyshev (97.5% KM-Cheby); 99% KM Chebyshev (99% KM-Cheby);
95% KM Percentile Bootstrap (95% KM-% Btstrp); 95% KM-t (95% KM-t); 95% KM-BCA (95% KM-BCA); 95% H-UCL (95% H-UCL); 95% Chebyshev -Mean, SD- UCL (95% Cheby, Mean, SD);
97.5% Chebyshev -Mean, SD- UCL (97.5% Cheby, Mean, SD); 99% Chebyshev -Mean, SD- UCL (99% Cheby, Mean, SD); 95% UCL of Log-transformed Data (95% UCL-T)
95% Student's-t (95% Student's-t); 95% Modified-t (95% Modified-t); 95% UCL based on bootstrap statistic (95% UCL-Bst); 95% Approximate Gamma UCL (95% Approx. Gamma).

[4] Unless otherwise noted (see footnote 5), ProUCL EPC selection rationale based on, detection limit values, distribution, standard deviation, and sample size (see ProUCL output in appendix for further details):
Test (1): Kaplan-Meier method recommended by ProUCL due to multiple detection limits.
Test (2): 95% UCL recommended by statistical software (e.g., ProUCL) exceeds maximum detected concentration, therefore, maximum concentration used for EPC.
Test (3): Shapiro-Wilk W test, Kolmogorov-Smirnov (K-S), and Anderson-Darling (A-D) tests, indicate data follow nonparametric distribution.
Test (4): Shapiro-Wilk W test indicates data are normally distributed.
Test (5): Shapiro-Wilk W test indicates data are log-normally distributed.
Test (6): Kolmogorov-Smirnov (K-S) and/or Anderson-Darling (A-D) tests indicate data follow gamma distribution.
Test (7): Sample size is less than or equal to 5, therefore, maximum concentration used for EPC.

[5] Infrequent detection resulted in ProUCL modeling error for this constituent, therefore distribution, average, and UCL determined using non-ProUCL bootstrap method with random numbers for NDs (see text for details).

noted that plants (and invertebrates) are included in the SLERA as media through which the wildlife receptors may be exposed indirectly to COPECs in the soil by means of the food chain.

7.3.3.2 Predictive Risk Estimation for Terrestrial Wildlife

The potential wildlife risks associated with SWMU 49 are estimated in this section. The risk estimation has been performed through a series of quantitative HQ calculations that compare receptor-specific exposure values with TRVs. The EEQs (or HQs) are compared to HQ guidelines for assessing the risk posed from contaminants. It should be noted that HQs are not measures of risk, are not population-based statistics, and are not linearly-scaled statistics, and therefore an HQ above 1, even exceedingly so, does not guarantee that there is even one individual expressing the toxicological effect associated with a given chemical to which it was exposed (Allard et al., 2007; Tannenbaum, 2001; Bartell, 1996).

The simple HQ ratios are summed to provide conservative HI estimates for chemicals and exposure pathways for a given receptor. The criterion used to decide if HQ summation is appropriate and scientifically defensible includes those chemicals that have a similar mode of toxicological action. While individual contaminants may affect distinct target organs or systems within an organism, classes of chemicals may act in similar ways, thus being additive in effect.

The summation of HQs into an HI was performed in this SLERA as a conservative approach. To assess whether or not individual COPEC HQs should be segregated based on dissimilar modes of toxicological action, individual COPEC effects were evaluated. However, as risk drivers resulted in HQs ranging from less than 1 to 2,888 (see following paragraphs), segregation of COPECs by mode of toxicological action was not necessary.

Tier 1 and Tier 2 individual COPEC EEQs and HIs (summed EEQs) for terrestrial receptors at SWMU 49 are presented in risk characterization tables (**Appendix F-2, Tables F-12 through F-21**) for the five selected receptor species. These summed EEQs are presented in **Table 7-16** (generally rounded to two significant figures), along with the hazard driver [COPEC(s) contributing the majority of the total estimated EEQ] and the exposure pathway of concern (the pathway contributing the most to the total estimated EEQ). An example EEQ calculation is presented **Appendix F-2, Table F-22**.

Table 7-16
Wildlife EEQ Hazard Summary for Food Chain Exposure at SWMU 49

Receptor	**Tier 1**[a]		**Tier 2**[b]	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
Meadow vole	99	50	25	13
Hazard Driver(s)[c]:	Selenium - plant ingestion		Selenium - plant ingestion	
Short-tailed shrew	2,888	358	22	4
Hazard Driver(s)[c]:	TCDD - terrestrial invertebrate ingestion		Selenium and TCDD - terrestrial invertebrate ingestion	

Table 7-16 (Continued)
Wildlife EEQ Hazard Summary for Food Chain Exposure at SWMU 49

Receptor	Tier 1[a]		Tier 2[b]	
	NOAEL-Based EEQ	LOAEL-Based EEQ	NOAEL-Based EEQ	LOAEL-Based EEQ
American robin	313	65	5	1.3
Hazard Driver(s)[c]:	Mercury, TCDD, Selenium, and Zinc - plant and terrestrial invertebrate ingestion		Zinc and Selenium - plant and terrestrial invertebrate ingestion	
Red-tailed hawk	108	50	0.004	0.002
Hazard Driver(s)[c]:	Selenium - small mammal ingestion		--	
Red fox	454	220	0.008	0.004
Hazard Driver(s)[c]:	Selenium - small mammal ingestion		--	

[a] Tier 1 = Max EEQ using max EPC, max BAF/BCF, max Intake Rates, min BW, and FHR =1.

[b] Tier 2 = EEQ using 95% EPC, non-max BAF/BCF, avg Intake Rates, avg BW and calculated FHR less than or equal to 1.

[c] Hazard drivers are those chemicals contributing the most to the total estimated EEQ, and the primary route of exposure associated with this driver.

Notes:

EEQ = Ecological Effects Quotient

LOAEL = Lowest-Observed-Adverse-Effect Level

NOAEL = No-Observed-Adverse-Effect Level

As shown in **Table 7-16**, Tier 1 total EEQs ranged from approximately 50 to 2,888 for the five receptor species, using TRVs based on either NOAEL or LOAEL values. The short-tailed shrew was predicted to be the most impacted, followed by the red fox, the American robin, the red-tailed hawk, and the meadow vole. The inorganic constituents mercury, selenium, and zinc; and the organic constituent TCDD were the COPECs contributing the most to the total EEQs for each of the receptors. Exposure pathways of most concern, based on the results of the Tier 1 food chain modeling, were plant, terrestrial invertebrate, and small mammal ingestion.

More realistic Tier 2 total EEQs were also elevated, especially values based on NOAEL TRVs, which ranged from 0.004 to 25. However, Tier 2 total EEQs were much lower than Tier 1 total EEQs, and both the NOAEL and LOAEL Tier 2 total EEQs for the red-tailed hawk and red fox were below 1. Tier 2 total EEQs based on LOAEL values were 13 for the meadow vole, 4 for the short-tailed shrew, and 1.3 for the American robin (**Table 7-16**). Selenium was identified as the main hazard driver for the meadow vole based on plant ingestion and TCDD and selenium were the hazard drivers for the short-tailed shrew based on invertebrate ingestion. No individual constituent LOAEL Tier 2 EEQs exceeded 1 for the American robin.

The specific results of the Tier 2 risk estimation for the meadow vole, short-tailed shrew, and American robin are discussed below. The specific results for the red-tailed hawk and red fox are not discussed because the summed EEQs are below 1.

Meadow Vole. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (25 and 13, respectively). Three COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): selenium (18.4), TCDD (2.5), and arsenic (2.1). Only selenium (11.1) had a LOAEL-based EEQ that exceeded 1. The primary exposure pathway was the ingestion of plants.

The results of the Tier 2 risk evaluation for meadow voles are presented in **Appendix F-2, Table F-13**.

Short-tailed Shrew. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (22 and 4, respectively). Three COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): TCDD (15.4), selenium (2.7), and arsenic (1.2). Two COPECs had individual LOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): selenium (1.6) and TCDD (1.5). The primary exposure pathway was the ingestion of terrestrial invertebrates. The results of the short-tailed shrew Tier 2 risk evaluation are presented in **Appendix F-2, Table F-15**.

American Robin. The total EEQs for both NOAEL and LOAEL TRVs exceeded 1 (5 and 1.3, respectively). Two COPECs had individual NOAEL-based EEQs that exceeded 1 (EEQ in parenthesis): zinc (1.4) and selenium (1.2). No COPECs had individual LOAEL-based EEQs that exceeded 1. The primary exposure pathway was the ingestion of terrestrial invertebrates and plants. The results of the Tier 2 risk evaluation for American robins are presented in **Appendix F-2, Table F-17**.

7.3.4 Approach for the Evaluation of Direct Contact Toxicity

To evaluate direct contact exposure, for those organisms that live within an environmental medium, COPEC media concentrations are compared with BTAG-approved direct contact screening values, and secondarily, a variety of additional appropriate direct contact benchmarks. Surface soil was the only exposure medium at SWMU 49. Intake is not calculated because potential adverse effects are assessed by evaluating the COPEC concentrations in soil. Detailed procedures are presented in *Section 7.1.8*, and the results are summarized in **Table 7-17**.

7.3.4.1 Soil

Based on the results of the first step, 14 COPECs were selected based on an EcoSSL or BTAG exceedance while 12 additional chemicals were evaluated further because of the lack of available EcoSSL or BTAG screening values (**Table 7-17**). In the second step, the MDC of these 26 chemicals was compared with up to five individual soil screening values. The results of the second screening step are as follows:

- There were no available benchmarks available for 1-methylnaphthalene; 2-methylnaphthalene; 2,4-DB; acetone; bis(2-ethylhexyl)phthalate; endrin; endrin aldehyde; calcium; and potassium.
- There were no additional benchmark values available for dieldrin. The EcoSSL guidance (USEPA, 2010d) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- The phenanthrene MDC exceeded the one available phenanthrene benchmark; however, the basis of the 0.1 mg/kg CCME benchmark was agricultural land use that is not appropriate for SWMU 48. The next highest CCME benchmark was 5 mg/kg for residential/parkland use, but this benchmark is not exceeded by the phenanthrene MDC. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 48.

Table 7-17
Direct Toxicity Evaluation for Surface Soil at SWMU 49
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Chemical (1)	Detection Frequency	Maximum Concentration	Exposure Point Concentration	Minimum Concentration	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	NOAA SQuiRT Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded	Comment
2,3,7,8-TCDD TE	4/4	2.62E-05	2.62E-05	2.79E-06	1.00E-02	No								
1-Methylnaphthalene	2/4	6.54E-02	6.54E-02	4.95E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
2-Methylnaphthalene	2/6	1.17E-01	1.17E-01	6.07E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
2,4-DB	1/6	9.21E-02	9.21E-02	9.21E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
4,4'-DDD	1/6	1.01E-03	1.01E-03	1.01E-03	2.10E-02	No								
Acetone	2/5	7.07E-02	7.07E-02	5.89E-02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Anthracene	1/9	1.00E-03	1.00E-03	1.00E-03	1.00E-01	No								
Aroclor 1254	3/6	1.24E-01	8.03E-02	1.09E-02	1.00E-01	Yes	Plant tox (no ref)	4.00E+01	5.00E-01	NVA	4.00E+01	NVA	0/3	No exceedences
Aroclor 1260	2/6	1.52E-01	1.52E-01	7.32E-02	1.00E-01	Yes	Plant tox (no ref)	4.00E+01	5.00E-01	NVA	4.00E+01	NVA	0/3	No exceedences
Benzo(a)anthracene	1/9	6.10E-03	6.10E-03	6.10E-03	1.00E-01	No								
Benzo(a)pyrene	1/9	4.90E-03	4.90E-03	4.90E-03	1.00E-01	No								
Benzo(b)fluoranthene	2/9	2.11E-02	2.11E-02	9.90E-03	1.00E-01	No								
Benzo(g,h,i)perylene	1/6	2.90E-03	2.90E-03	2.90E-03	1.00E-01	No								
Benzo(k)fluoranthene	1/9	4.20E-03	4.20E-03	4.20E-03	1.00E-01	No								
bis(2-Ethylhexyl) phthalate	1/9	1.20E+00	4.17E-01	1.20E+00	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Chrysene	6/9	7.90E-02	4.48E-02	1.10E-03	1.00E-01	No								
Dibenz(a,h)anthracene	1/9	2.30E-03	2.30E-03	2.30E-03	1.00E-01	No								
Dieldrin	1/6	9.45E-03	6.88E-03	9.45E-03	4.90E-03	Yes	Mammal tox	NVA	NVA	NVA	NVA	NVA	1/1 (only EcoSSL)	EcoSSL says data insufficient to derive direct contact SSL
Di-n-butyl phthalate	2/9	1.28E-01	1.28E-01	1.23E-01	NVA	NVA		NVA	NVA	NVA	2.00E+02	NVA	0/1	No exceedences
Endosulfan II	1/6	7.22E-03	7.22E-03	7.22E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Endosulfan sulfate	1/6	6.64E-03	6.64E-03	6.64E-03	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Endrin	1/6	7.57E-04	7.57E-04	7.57E-04	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Endrin aldehyde	1/6	7.23E-04	7.23E-04	7.23E-04	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Fluoranthene	2/9	1.40E-02	1.40E-02	1.30E-03	1.00E-01	No								
Fluorene	1/6	1.50E-03	1.50E-03	1.50E-03	1.00E-01	No								
Indeno(1,2,3-cd)pyrene	1/9	3.40E-03	3.40E-03	3.40E-03	1.00E-01	No								
Phenanthrene	6/9	3.10E-01	1.87E-01	2.60E-03	1.00E-01	Yes	BTAG based on benzo(a)pyrene mouse study	NVA	1.00E-01	NVA	NVA	NVA	1/1	BTAG based on benzo(a)pyrene study
Pyrene	2/9	1.00E-02	1.00E-02	1.10E-03	1.00E-01	No								
Aluminum	6/6	2.89E+04	2.28E+04	9.22E+03	1.00E+00	Yes	pH < 5.5; Plant tox (OHMTADS)	NVA	NVA	NVA	5.00E+01	NVA	1/1	pH = 4.81, plant tox
Arsenic	8/9	8.20E+00	4.95E+00	5.20E-01	1.80E+01	No								
Barium	9/9	1.19E+02	9.40E+01	5.30E+01	3.30E+02	No								
Beryllium	8/9	7.40E-01	6.55E-01	5.20E-01	2.10E+01	No								
Calcium	6/6	1.44E+03	1.09E+03	3.21E+02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Chromium (Cr III tox)	9/9	3.03E+01	2.18E+01	1.18E+01	2.60E+01	Yes	Bird tox (Cr III)	3.80E-01	6.40E+01	NVA	1.00E+00	4.00E-01	3/4	EcoSSL says data insufficient to derive direct contact SSL
Chromium (Cr VI tox)	9/9	3.03E+01	2.18E+01	1.18E+01	1.30E+02	No								
Cobalt	6/6	5.75E+00	5.20E+00	3.10E+00	1.30E+01	No								
Copper	6/6	1.76E+01	1.68E+01	5.49E+00	2.80E+01	No								
Iron	6/6	3.26E+04	2.64E+04	9.06E+03	5 ≤ pH ≤ 8	Yes		NVA	NVA	NVA	NVA	NVA		pH = 4.81
Lead	9/9	7.16E+01	5.65E+01	1.34E+01	1.10E+01	Yes	Bird tox	5.50E+01	7.00E+01	1.20E+02	5.00E+01	5.00E+02	3/5	
Magnesium	6/6	1.12E+03	1.02E+03	5.12E+02	4.40E+03	No								
Manganese	6/6	5.70E+02	4.32E+02	1.30E+02	2.20E+02	Yes	Plant tox	NVA	NVA	2.20E+02	5.00E+02	NVA	2/2	Plant tox
Mercury	6/7	4.97E-01	3.03E-01	4.80E-02	5.80E-02	Yes	No reference	3.00E-01	6.60E+00	NVA	3.00E-01	1.00E-01	3/4	No reference for BTAG
Nickel	9/9	1.07E+01	9.12E+00	5.33E+00	3.80E+01	No								
Potassium	3/3	1.12E+03	1.12E+03	5.08E+02	NVA	NVA		NVA	NVA	NVA	NVA	NVA		
Selenium	5/9	9.40E+00	6.62E+00	6.68E-01	5.20E-01	Yes	Plant tox	7.00E-01	1.00E+00	5.20E-01	1.00E+00	7.00E+01	5/5	Plant tox
Silver	2/8	2.62E-02	2.62E-02	2.22E-02	5.60E+02	No								
Thallium	2/9	1.30E-01	1.30E-01	1.00E-01	1.00E-03	Yes	Plant tox (no ref)	1.00E+00	1.00E+00	NVA	1.00E+00	NVA	0/3	No exceedences

Table 7-17
Direct Toxicity Evaluation for Surface Soil at SWMU 49
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Chemical (1)	Detection Frequency	Maximum Concentration	Exposure Point Concentration	Minimum Concentration	BTAG or USEPA EcoSSL Screening Toxicity Value (2)	Retain COPEC as Max Conc > BTAG or EcoSSL Value?	If Retained as COPEC, Comment on BTAG or EcoSSL Value	NOAA SQuiRT Value (3)	CCME Value (4)	USEPA EcoSSL Direct Contact Value (5)	ORNL Screening Benchmark for Plants (6)	ORNL Screening Benchmark for Invertebrates (7)	COPEC Weight of Evidence Summary - Number of Direct Contact Benchmarks Exceeded	Comment
Vanadium	6/6	6.39E+01	5.30E+01	2.03E+01	7.80E+00	Yes	Bird tox	4.20E+01	1.30E+02	NVA	2.00E+00	NVA	2/3	EcoSSL says data insufficient to derive direct contact SSL
Zinc	6/6	5.65E+01	5.25E+01	2.33E+01	1.00E+01	Yes	Plant tox (OHMTADS)	1.60E+01	2.00E+02	1.20E+02	5.00E+01	2.00E+02	3/6	Plant tox

All values presented in mg/kg.

NVA = No Value Available

Surface soil pH of SWMU 49 is 4.81 based on one geochemical sample (49SS01) collected at SWMU 49.

(1) COPECs from Table 7-13.

(2) Screening toxicity values from BTAG (1995b) or EcoSSL (USEPA, 2010d). EcoSSLs given highest priority as they are more definitive.

(3) NOAA SQuiRT (Buchman, 2008).

(4) Lowest value from Canadian Council of Ministers of the Environment (CCME), Canadian Environmental Quality Guidelines, December 2003.

(5) Lowest EcoSSL value for direct contact toxicity for either plants or terrestrial invertebrates (USEPA, 2010d).

(6) Screening benchmarks for plants from ORNL (1997, ES/ER/TM-85/R3).

(7) Screening benchmarks for earthworms from ORNL (1997, ES/ER/TM-126/R2).

- The aluminum MDC exceeded the one available benchmark for plant toxicity, and the soil pH at SWMU 49 is 4.81. USEPA (USEPA, 2010d) recommends that aluminum should only be identified as a COPEC in soils with a pH of less than 5.5. Therefore, the potential for direct plant contact toxicity is a potential concern at SWMU 49. However, as discussed in *Section 7.3.3.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- The chromium MDC exceeded three of the four available benchmarks for Cr(III); however, the EcoSSL guidance (USEPA, 2010d) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- Iron is a potential concern at SWMU 49 because the soil pH of 4.81 is outside the range of 5 to 8. Due to the acidic soil conditions, iron may be toxic to plants (USEPA, 2010d). However, as discussed in *Section 7.3.3.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- The lead MDC exceeded three of the five available benchmarks for direct toxicity. Therefore, there is potential for direct contact toxicity for lead at SWMU 49. This may or may not result in the reduction of terrestrial invertebrates as a food source at SWMU 49.
- The manganese MDC exceeded the two available benchmarks; however, no reference is available to determine the basis or appropriateness of the BTAG value. The EcoSSL and ORNL exceedances were for plant toxicity, and as discussed in *Section 7.3.3.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- The mercury MDC exceeded three of the four available benchmarks. Therefore, there is potential for direct contact toxicity for mercury at SWMU 49. This may or may not result in the reduction of terrestrial invertebrates as a food source at SWMU 49.
- The selenium MDC exceeded all five available benchmarks; however, the exceedance was for plant toxicity, and as discussed in *Section 7.3.3.1*, plant toxicity is not an overriding concern for the site. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- The vanadium MDC exceeded two of the three available benchmarks; however, the EcoSSL guidance (USEPA, 2010d) says that data are insufficient to derive a direct contact benchmark for this inorganic constituent. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.
- The zinc MDC exceeded one of the six available benchmarks; however, the exceedance was for plant toxicity, and as discussed in *Section 7.3.3.1*, plant toxicity is not an overriding concern for the site. In addition, the ORNL (1997a) values for plants are outdated, and the current plant benchmark (from USEPA, 2010d; 160 mg/kg) is not exceeded. Therefore, the potential for direct contact toxicity is not significant enough to recommend further action at SWMU 49.

- None of the other COPECs selected in the first screening step had any benchmark exceedances.

These results suggest that direct contact toxicity for COPECs in soil may be a concern for lead and mercury. It should also be noted that toxicity to terrestrial invertebrates is assessed indirectly, as terrestrial invertebrates such as earthworms are included in the food chain models used in the assessments.

7.3.5 Background Metals Considerations

A background evaluation was conducted on the soil analytical results to determine if any inorganic COPEC drivers discussed in the previous sections were potentially related to naturally-occurring soil concentrations. From the Tier 2 LOAEL assessment, the only inorganic COPEC driver with an EEQ greater than 1 for the food chain assessment was selenium. COPEC hazard drivers for the direct contact assessment were lead and mercury. As summarized in **Table 7-18**, mercury and selenium COPECs in SWMU 49 surface soil are the only constituents considered to be potentially site related and not attributed to background. Details of the background evaluation are presented in *HHRA Section 6.4.3*, **Tables 6-6 and 6-7** and **Appendices E-9 and E-10**.

Table 7-18
Background Comparison for Surface Soil at SWMU 49

Soil COPEC	Wilcoxon Mann Whitney Test Site > Background?	Considered to be Background?
Lead	No	Yes
Mercury	Yes	No
Selenium	Yes	No

7.3.6 Uncertainty Analysis

There were 132 chemical constituents not detected in surface soil analytical samples. **Appendix F-2, Table F-30** evaluates the uncertainty associated with these constituents' detection limits by presenting a comparison of the maximum detection limit for each non-detect constituent with a conservative ecological toxicity screening value. Ecological screening values were compiled and presented in **Appendix F-2, Table F-31**.

Forty-two of the non-detect constituents had maximum detection limits that exceeded either one or both of the screening criteria. This finding is not unexpected, given the conservative and numerically low screening values.

Two COPECs (selenium and TCDD) had Tier 2 LOAEL-based EEQs that exceeded 1 when round to one significant figure (i.e., the meadow vole had an estimated selenium EEQ of 11.1, while the shrew had an estimated selenium EEQ of 1.6 and an estimated TCDD EEQ of 1.5). Given the uncertainties associated with the SLERA process, the key parameters associated with these elevated EEQs were examined in more detail in the following sections.

<u>Selenium</u>. For selenium, the elevated meadow vole EEQ of 11.1 was primarily from the plant ingestion pathway (96 percent). The LOAEL of 0.33 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 4 (**Appendix F-2, Table F-28**). The use of this UF is conservative, and the elimination of this UF

would result in the selenium EEQ of 11.1 dropping to approximately 3 (still above a level of potential concern).

For the slightly elevated shrew EEQ of 1.6, the primary exposure was from the invertebrate ingestion pathway (84 percent). The LOAEL of 0.33 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-28**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 4 would result in the selenium EEQ of 1.6 dropping below 1.

<u>TCDD</u>. For the slightly elevated shrew EEQ of 1.5, the primary exposure was from the invertebrate ingestion pathway (98 percent). The LOAEL of 1E-5 mg/kg-day that was used was based on a laboratory rat study from Sample et al. (1996) and the use of a toxicity extrapolation UF of 8 (**Appendix F-2, Table F-28**). The use of this UF is quite conservative, and the use of an alternative UF of approximately 4 would result in the TCDD EEQ of 1.5 dropping below 1.

Given the extremely small size of the site (0.1 acres), the remaining elevated EEQ for the meadow vole (estimated to be approximately 3 for selenium if the toxicity extrapolation UF is dropped) may not be a concern. This is because the small size of the site may not support enough breeding pairs of voles for reproductive success; therefore, contamination such as selenium would be irrelevant. The reported vole density based on literature values averages approximately 210 per acre (USEPA, 1993), so for the 0.1-acre site, the expected number of voles would be about 21, or about 10 males and 10 females at an optimal 50%-50% male to female ratio. However, male to female ratios are rarely optimal in the field, so it is possible the site is not large enough to sustain a successful breeding population of voles.

7.3.7 SLERA Results and Conclusions

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 49. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-16**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-17** and discussed in *Section 7.3.4.1*.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews and voles for modeled contact with the hazard drivers (primarily selenium and TCDD) in surface soil. Use of alternative SLERA parameters would reduce the estimated Tier 2 LOAEL-based EEQs to essentially 1, except for selenium exposure for the meadow vole. However, the small size of the site may not be able to support enough small mammals for a sustainable breeding population. The direct contact assessment results suggest a potential reduction in terrestrial invertebrate wildlife food supply due to lead and mercury in surface soil; however, given the small size of the site, it is unlikely that the potential loss of prey would be biologically significant. Analysis of the site and background data indicates that of the three inorganic COPEC drivers, lead is background related [i.e., statistically related to naturally-occurring surface soil concentrations (*Section 7.3.5*)].

Based on uncertainties of toxicity, the potential that lead concentrations are background related, the fact that no wildlife RTE species have been confirmed at the SWMU study area, and the relatively small size of the site (0.1 acre), remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

Migration of COPECs in groundwater to surface water and sediment of the New River was determined unlikely due to the distance of this receptor area from the site and therefore was not deemed to be an ecological concern.

The assessment results may serve as the foci of discussions with risk managers and regulatory agencies. It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

8.0 CONCLUSIONS

Shaw conducted an RFI at SWMU 48 (RAAP-18) - the Oily Water Burial Area and SWMU 49 (RAAP-13) - Red Water Ash Burial #2 during 2007. These investigations are required by the 2000 RCRA Corrective Action permit (USEPA, 2000a) for RFAAP and were performed in accordance with *MWP Addendum 019* (Shaw, 2007). MWP Addendum 019 was prepared to facilitate the investigation effort to comply with the requirements set forth in the 2000 RCRA Corrective Action permit and was approved by the USEPA Region III and the VDEQ.

Previous investigations combined sites SWMUs 48, 49, 50, and 59 into one combined study area. SWMUs 50 and 59 were addressed in a separate RFI (Shaw, 2009) that recommended No Further Action and was approved by the USEPA and VDEQ in October 2009. SWMUs 48 and 49 are associated because in previous reports their descriptive titles have been mixed-up and because of their close proximity to each other. The groundwater samples collected from wells at SWMUs 13, 48, 49, 50, and 59 were all assessed in this report since the sites are so close in proximity and the contamination appears to be originating from SWMU 49.

In addition to the MWP Addendum 019 field investigation, six previous field investigations were conducted at SWMUs 48 and 49 between 1987 and 2006. These investigations provide a comprehensive, long-term dataset that, in conjunction with the current data, can be used to assess concentrations over time.

During the development of MWP Addendum 019, a review of the data indicated that additional wells were needed to constrain the extent of constituents in groundwater. In addition, groundwater samples from previous investigations at the combined study area had not been analyzed for perchlorate or herbicides, representing another data gap. Additional soil sampling at SWMU 49 was performed to provide additional data for a risk assessment at that site. Soil at SWMU 48 was considered sufficiently characterized through the sampling performed in the previous investigations.

2007 RFI activities included the installation of four new monitoring wells and the collection and chemical analysis of groundwater samples from the new and existing wells in the area. Four surface soil samples and three subsurface soil samples were also collected from SWMU 49.

After regulatory review of an earlier version of the draft RFI, a supplemental data investigation was conducted in 2010 and consisted of the advancement of a series of test pits perpendicular to the trenches at SWMU 48 and subsurface soil sampling. Although the elevated detection of 2,4,6-TNT from 1998 could not be duplicated during the investigation, bags of an unknown clayey substance found to contain high metals concentrations were uncovered. Based on the discovery of the bags and the high concentrations of metals detected in the clayey substance, an Interim Measures Removal Action was performed in 2011 and, impacted soil, the ash layer, and debris, including the clayey substance, were removed from the southern trench of SWMU 48 and disposed of offsite.

Review of the 2007 RFI groundwater data indicated that further investigation was required to delineate the extent of chlorinated solvents in groundwater in the SWMU 48/49 area. In an effort to complete the RFI at these sites, a Supplemental RFI was performed in 2013 that included the installation of four additional groundwater monitoring wells to the south and east of the SWMUs 48 and 49. These four new wells and 10 existing wells were sampled in May 2013 to further define the extent of chlorinated solvents in groundwater.

8.1 Contamination Assessment

8.1.1 Soil

8.1.1.1 SWMU 48

The primary concern in soil at SWMU 48 was 2,4,6-TNT and 2,4-DNT, located within a thin ash layer near the base of the southern trench during the 1998 RFI. Concentrations of explosives above SLs were limited to three samples collected in the southern trench. Subsurface samples 48SB07A (8-9 ft bgs) and 48TP1 (6-6.5 ft bgs) were both collected from soil containing ash. Sample 48SB7B (10-11 ft bgs) was collected directly below sample 48SB7A and indicated a marked decrease in the concentration of 2,4,6-TNT.

Shaw conducted a supplemental data investigation and additional sampling in 2010 to visibly locate the ash layer within the SWMU 48 trenches via test pitting and characterize the concentrations of explosives in the soil above, within, and below the ash layer. Visual observations during the test pitting indicated that the thickness of the ash layer generally ranged from approximately 0.3 to 2.0 ft and also demonstrated that the ash layer was present through much of the length of the southern trench. In addition, lenses of plastics, roofing materials, asphalt debris, and an unknown green clayey substance were encountered in some of the test pits. Sample results from the investigation indicated that the elevated TNT levels detected in 1998 were isolated and anomalous results that could not be replicated. Test pit sample results also indicated that metal concentrations, specifically, lead, antimony, arsenic, cadmium, copper, and mercury, were present at concentrations posing a threat to human health and the environment at SWMU 48.

Based upon the 2010 investigation sample results, an interim measures remedial action was performed to address the elevated concentrations of metals in SWMU 48 soil. In compliance with the *SWMU 48 Interim Measures Work Plan* (Shaw, 2011), the source material for contamination at SWMU 48, the debris and ash layer was removed. As presented in the *SWMU 48 Interim Measures Completion Report* (Shaw, 2012), sample results from XRF screening and laboratory confirmation samples indicated that all contaminated soils had been removed to or below the industrial RGs selected for arsenic, antimony, cadmium, copper, lead, and mercury. The cleanup efforts at SWMU 48 achieved residential soil RGs and the site is now suitable for unrestricted re-use. Therefore, soil at SWMU 48 is not considered a concern.

8.1.1.2 SWMU 49

The soil at SWMU 49 was investigated during five investigation efforts spanning from 1991 through 2007 in support of RFIs. Sample results from the investigations indicated that VOCs, PAHs, pesticides, explosives, herbicides, metals, and dioxins/furans were not detected at concentrations above r-SLs or i-SLs in any of the soil samples collected at the site and are not considered a concern in soil at SWMU 49. The only analytes detected above SLs included two SVOCs [bis(2-ethylhexyl)phthalate and naphthalene], two PCBs (PCB-1232 and PCB-1254), and TPH. Bis(2-ethylhexyl)phthalate was only detected in one soil sample at a concentration marginally above its r-SL (but below its i-SL).

As previously discussed, bis(2-ethylhexyl)phthalate is a common laboratory contaminant that is not site related, and its presence in a single soil sample above its r-SL is not a concern in soil at the site. Naphthalene was detected above its r-SL (but below its i-SL) in one subsurface soil sample and above its i-SL in one other subsurface soil sample (48SB5A19). Naphthalene was not detected in subsurface soil sample 48SB5B37, collected below 48SB5A19, where naphthalene was detected above its i-SL; this indicates that naphthalene is not vertically migrating and its presence at an elevated concentration in a couple site soil samples is isolated and not considered a concern in site soil.

The most likely source for PCBs in soil was the oily water that was reportedly disposed of in the SWMU 48/49 area. PCBs are highly immobile in the environment and their presence at that depth (and not shallower) is likely due to the fact that the PCBs were entrained with the oily water when it was dumped. The low mobility of PCBs appears to have caused the PCBs to bind to soil particles, thus preventing downward migration. Groundwater sample results from the 2007 RFI sampling effort indicate that PCBs were not detected in any of the 11 groundwater samples collected at the combined study area. Therefore, PCBs are not considered a concern in soil or groundwater at SWMUs 48 or 49.

Similar to the potential source for PCBs detected in soil at the site, it is likely that the source for the TPH in soil was the oily water that was reportedly disposed of in the SWMU 48/49 area. Other than the single occurrence of TPH at an elevated concentration in one site surface soil sample, elevated TPH concentrations were isolated to two subsurface soil samples collected from 17 to 19 ft bgs. Subsurface soil results from samples collected below 17 to 19 ft bgs in the same boring indicate that TPH was not detected, demonstrating that elevated concentrations of TPH are isolated and not migrating downward. In addition, the elevated concentrations of TPH at 17 to 19 ft bgs are present at depths below what human and ecological receptors are exposed.

8.1.2 Groundwater

The contamination assessment and the HHRA identified several VOCs and metals as elevated and contributing to potential future risks. Two of the VOCs associated with potential future industrial and residential risk in the HHRA (CT and TCE) were present above USEPA’s MCLs (USEPA, 2006) during the multiple groundwater sampling events at the combined study area. The highest VOC concentrations of CT and TCE were found in wells 48MW2 and 48MW3, where the center of the plumes is located. The CT plume is oval in shape, approximately 250 ft in length (north to south) and 680 ft wide (east to west), and is delineated in all directions. The center of the plume (highest detected concentrations) is located approximately 205 ft southeast of SWMU 49. The upgradient edge of the plume is located approximately 250 ft to the northwest from the center of the plume. The TCE plume is triangular in shape, is approximately 560 ft in length (north to south) and 580 ft wide (east to west), and is delineated in all directions. The center of the plume (highest detected concentrations) is located approximately 210 ft southeast of SWMU 49. The upgradient edge of the plume is located approximately 300 ft to the northwest from the center of the plume and extends into SWMU 48.

A comparison in concentrations from the mid-1990s to 2013 indicates that the majority of the VOCs are no longer present in these sampled areas and have broken down through natural processes. Analysis of the groundwater data during this roughly 20 year period shows that concentrations of CT and TCE plume have: 1) decreased overall, 2) decreased to 1 µg/L surrounding the center of the plume, and 3) decreased at least by one half in the center of the plume. The presence of daughter products (i.e., chloroform and cis-1,2-DCE) in groundwater at the combined study area indicates that limited biological degradation of the chlorinated solvents is occurring.

8.2 Human Health Risk Assessment

An HHRA (*Section 6.0*) was conducted at SWMUs 48 and 49 to evaluate the potential human health risks associated with previous activities at the site. Risks associated with surface soil, total soil and groundwater were evaluated for several different current and hypothetical future exposure scenarios. Risks and hazards from these scenarios are summarized below.

8.2.1 SWMU 48

At SWMU 48, the total cancer risk for current and future maintenance worker, future industrial worker and future excavation worker exposures to surface soil were within or below the target risk range of 1E-06 to 1E-04. The total HIs were less than 1. For current and future maintenance worker and future excavation worker, the total cancer risk associated with groundwater was below the target risk range and the total HI was less than 1. For the future industrial worker, the total cancer risk associated with groundwater (1E-04) was equal to the upper limit of the target risk range of 1E-06 to 1E-04. The total HI (2E+01) was above 1, primarily due to cobalt, iron, manganese, and thallium. The MDC and the arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For the future lifetime resident (and offsite resident), the total cancer risks associated with total soil (1E-05) were within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. For future adult residents, the total HI for total soil was less than 1. The total cancer risk associated with groundwater (2E-03) was above the target risk range of 1E-06 to 1E-04. For future adult resident exposures, the total HI (9E+01) was above 1. The MDC for lead in groundwater was above the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For the child resident, the total cancer risks associated with total soil (9E-06) was within the target risk range, primarily due to arsenic. Arsenic has been determined to be within background concentrations for total soil. For future child residents, the total HI (4E+00) was above 1; however, there were no individual COPCs with HIs above 1. The total cancer risk associated with groundwater (onsite and offsite) (6E-04) was above the target risk range of 1E-06 to 1E-04. For future child resident exposures, the total HI (1E+02) was above 1. It is noted that chemicals with a critical endpoint of harm to the developing fetus may have other less sensitive effects on other organs in children. For the residential scenario, site concentrations were above the health protective criterion for lead.

8.2.2 SWMU 49

At SWMU 49, the total cancer risk for current and future maintenance worker, future industrial worker and future excavation worker exposures to surface soil and/or total soil was within or below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. The total cancer risk for current and future maintenance worker and future excavation worker exposures associated with groundwater (onsite and offsite) was below the target risk range of 1E-06 to 1E-04. The total HI was less than 1.

The total cancer risk for future industrial worker exposures associated with groundwater (onsite and offsite) (1E-04) was equal to the upper limit of the target risk range of 1E-06 to 1E-04. The total HI (2E+01) was above 1. The MDC and arithmetic mean of lead in groundwater were greater than the action level for lead in drinking water.

For the future lifetime resident, the total cancer risks associated with total soil (5E-05) were within the target risk range. For future adult residents, the total HI for total soil was less than 1. The total cancer risk associated with groundwater (onsite and offsite) (2E-03) was above the target risk range of 1E-06 to 1E-04. For future adult resident exposures, the total HI (9E+01) was above the MDC and arithmetic mean of lead in groundwater was greater the action level for lead in drinking water. For the residential scenario, site concentrations were above the health protective criterion for lead.

For the future child resident, the total cancer risks associated with total soil (4E-05) was within the target risk range. The total HI (3E+00) was above 1; however, there were no individual COPCs with HIs above 1. The total cancer risk associated with groundwater (onsite and offsite) (6E-04) was above the target risk range of 1E-06 to 1E-04. The total HI (1E+02) was above 1. The margin-of-exposure evaluation for iron indicated that the iron intake was above the allowable range.

8.3 Screening Level Ecological Risk Assessment

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 48. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-9**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-10** and discussed in *Section 7.2.4.1*.

The food chain Tier 2 NOAEL assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews, robins, and voles for modeled contact with the hazard drivers (arsenic; chromium; lead; mercury; zinc; Aroclor 1254; 4,4-DDT; 4,4-DDD; and TCDD) in surface soil. Based on Tier 2 LOAEL-based approach, only chromium for the robin and TCDD for the shrew had estimated EEQs greater than 1 when rounded to one significant figure. In addition, when alternative exposure and/or toxicity factors were used in the SLERA EEQ calculation for these two receptors, estimated EEQs would be expected to drop to 1 or less. The direct contact assessment results suggest a potential reduction in wildlife food supply due to barium and mercury in surface soil; however, due to the small size of the site (1 acre), this potential reduction in food is not considered biologically significant. Analysis of the site and background data indicates that all of the Tier 2 inorganic COPEC drivers (chromium, mercury, and zinc) and the direct contact constituent mercury, are statistically related to naturally-occurring surface soil concentrations (*Section 7.2.5*).

Based on uncertainties of toxicity, the finding that chromium, mercury, and zinc concentrations are background related, the fact that no wildlife RTE species have been confirmed at the SWMU study area, alternative exposure and/or toxicity factors that could be used, and the relatively small size of the SWMU (1.0 acre), additional remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

The data, results, and conclusions of the SLERA evaluated risks to ecological populations inhabiting SWMU 49. Conclusions are derived from the risk assessment and are based on the responses to the assessment hypotheses and assessment endpoints. The assessment results for food chain exposure are summarized in **Table 7-16**, and direct contact exposure results for terrestrial invertebrates, which may serve as a food source for wildlife are summarized in **Table 7-17** and discussed in *Section 7.3.4.1*.

The food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews and voles for modeled contact with the hazard drivers (primarily selenium and TCDD) in surface soil. Use of alternative SLERA parameters would reduce the estimated Tier 2 LOAEL-based EEQs to essentially 1, except for selenium exposure for the meadow vole. However, the small size of the site may not be able to support enough small mammals for a sustainable breeding population. The direct contact assessment results suggest a potential reduction in terrestrial invertebrate wildlife food supply due to lead and mercury in surface soil; however, given the small size of the site, it is unlikely that the potential loss of prey would be biologically significant. Analysis of the site and background data indicates that of the three inorganic COPEC drivers, lead is background related [i.e., statistically related to naturally-occurring surface soil concentrations (*Section 7.3.5*)].

Based on uncertainties of toxicity, the potential that lead concentrations are background related, the fact that no wildlife RTE species have been confirmed at the SWMU study area, and the relatively small size of the site (0.1 acre), remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

For both SWMUs 48 and 49, migration of COPECs in groundwater to surface water and sediment of the New River was determined unlikely due to the distance of this receptor area from the site and therefore was not deemed to be an ecological concern.

The SWMU 48 and 49 assessment results may serve as the foci of discussions with risk managers and regulatory agencies. It is very important to note that many conservative assumptions and modeling approaches were used in the assessment, and actual hazards to wildlife may be orders of magnitude lower than predicted herein.

8.4 Recommendations

8.4.1 Soil

8.4.1.1 SWMU 48

As presented in the *SWMU 48 Interim Measures Completion Report* (Shaw, 2012), soil constituents have been remediated to below industrial standards. Additionally, the cleanup efforts at SWMU 48 achieved residential soil RGs and the site is now suitable for unrestricted re-use. The Army requests a Response Complete determination for SWMU 48, as the results of the Interim Measures and the contamination assessment indicate that No Further Action is required for the site.

8.4.1.2 SWMU 49

The contamination assessment of SWMU 49 indicates that explosives, herbicides, metals, and dioxins/furans were not detected at concentrations above r-SLs or i-SLs in any of the soil samples collected at the site and are not considered a concern in soil at SWMU 49. The only analytes detected above SLs included two SVOCs [bis(2-ethylhexyl)phthalate and naphthalene], two PCBs (PCB-1232 and PCB-1254), and TPH. Analysis of the soil data indicates that these analytes are not considered a concern in soil at SWMU 49.

The HHRA indicated that the total cancer risk for current and future maintenance worker, future industrial worker and future excavation worker exposures to surface soil and/or total soil was within or below the target risk range of 1E-06 to 1E-04. The total HI was less than 1. For the future child resident, the total cancer risk associated with total soil (4E-05) was within the target risk range. The total HI (3E+00) was above 1; however, there were no individual COPCs with HIs above 1.

The SLERA indicated that the food chain assessment suggests potential adverse impacts to terrestrial wildlife, especially shrews and voles for modeled contact with the hazard drivers. The direct contact assessment results suggest a potential reduction in terrestrial invertebrate wildlife food supply due to lead and mercury in surface soil. Based on uncertainties of toxicity, the potential that lead concentrations are background related, the fact that no wildlife RTE species have been confirmed at the SWMU study area, and the relatively small size of the site (0.1 acre), remedial measures solely to address ecological concerns are not warranted for soil. The SMDP reached for this SLERA is that the information collected and presented indicates that a more thorough assessment is not warranted.

Based on the findings from the contamination assessment, HHRA, and the SLERA, the site is suitable for unrestricted use and No Further Action is recommended for soil at SWMU 49.

8.4.2 Groundwater

Groundwater at the combined study area has been investigated from the mid-1990s through 2013 and has been fully characterized and delineated. Based on the contamination assessment and the HHRA, CT and TCE are the primary constituents of concern that are contributing potential future industrial and residential risk at the combined study area. Results from the MNA analysis conducted for the combined study area groundwater (*Section 4.6*) indicated that MNA processes including biodegradation, sorption, dilution, dispersion, and chemical stabilization are occurring in groundwater at the combined study area. The following conclusions were derived from the MNA analysis:

- Decreases in TCE and CT concentrations have occurred from 1995 to 2013 and indicate that MNA processes are aiding in the reduction of contaminated concentrations.
- The presence of daughter products cis-1,2-DCE and chloroform suggests that limited biological degradation has occurred, which also may be aiding in removing mass in the groundwater.
- The geochemical parameters, including DO, ORP, anions, and TOC indicate that groundwater conditions are generally aerobic and not favorable for the complete biological reducing of TCE and CT.
- Additional sampling is required to obtain a more complete data set for the evaluation of site characteristics and further analyze contaminant concentrations in the combined study area.

Based on the findings from the contamination assessment, MNA analysis, and HHRA, long-term monitoring of the combined study area groundwater is recommended to further evaluate contaminant concentrations and MNA of contaminants in groundwater at the combined study area.

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